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Elk Creek Basin

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

ELK CREEK BASIN
NILAN EAST DAM
MT-14

WILLOW CREEK BASIN
NILAN NORTH DAM
MT-3206
AUGUSTA, MONTANA

PREPARED FOR:

THE HONORABLE TED SCHWINDEN
GOVERNOR OF THE STATE OF MONTANA

STATE OF MONTANA (OWNER)
NILAN WATER USERS ASSOCIATION (OPERATOR)

PREPARED BY:

MORRISON - MAIERLE, INC.
CONSULTING ENGINEERS

JULY 1981

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NILAN RESERVOIR

EXECUTIVE SUMMARY

Under contract with the Montana Department of Natural Resources and Conservation (DNR&C) and with representation from the Department of Natural Resources and Conservation and Nilan Water Users Association, Morrison-Maierle, Inc. inspected Nilan East Dam and Nilan North Dam on 31 July 1980 under the authority of Public Law 92-367. These dams form an offstream storage project located in a natural lake depression which is tributary to both the Willow Creek basin and the Elk Creek basin. The project is located in Lewis and Clark County about seven miles west of Augusta, Montana.

This report was compiled from information obtained during onsite inspections, review of construction plans and preconstruction notes, and analyses of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction and operation.

FINDINGS AND EVALUATION

The Nilan Project is owned by the State of Montana and is operated by the Nilan Water Users Association. The dams and reservoir are located on land deeded to the project and the reservoir is used for storage of irrigation waters and recreation. The project consists of a north dam controlling releases to the north canal in the Willow Creek basin and an east dam controlling releases to the east canal in the Elk Creek basin. The natural drainage basin is very small and inflow is controlled by a diversion structure and supply canal from Ford Creek. The east and north dams are 51 feet and 54 feet high respectively and are constructed to the same elevation, 4452.0 feet, National Geodetic Vertical Datum (NGVD). The two dams, designed by the State Water Conservation Board (now the DNR&C) in 1951, impound a total of 15,600 acre-feet of water at the dam crest elevation 4452.0 feet NGVD. Outlets at either dam could drain the majority of the reservoir contents. The north dam's outlet is three feet lower and therefore could drain the reservoir down to dead storage. All elevations used in this report are based on the assumed elevation 4400.75 feet NGVD at the invert of the east outlet pipe which corresponds to the project datum on the construction plans.

On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Reference 1), each dam is intermediate in size. The dams are located such that a failure of either dam could endanger lives and cause excessive economic loss. However, no dam breach analysis or routing of a dam breach flood was made for the areas downstream of either dam. The conclusions on probable damage are based on a brief field visit and engineering judgement.

The east and north dams are each classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Reference 1) recommend that an intermediate size project with a high downstream hazard potential

be capable of safely handling the full probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated probable maximum precipitation (PMP) was developed for the 3.55-square-mile drainage basin during this dam safety study. The project has a limited drainage area and is supplied by diverted flow from Smith Creek and Fork Creek. The PMF resulting from the 72-hour storm PMP has an estimated volume of 3290 acre-feet and a peak flow of 24,800 cfs. The emergency spillway for the project has a maximum discharge capacity of 8620 cfs with the reservoir at the top of dam, elevation 4452 feet. The routing of the PMF was started with the reservoir at the spillway crest. The routing indicates that the project will contain the entire PMF with the reservoir rising to a maximum elevation of 4447.2 feet which is 4.8 feet below the dam crest. This analysis assumes no discharge through the project's outlet works.

On the basis of the field inspection and study of hydrologic data, the Nilan Project conforms to Corps guidelines with respect to discharge and/or storage capacities to safely handle the spillway design flood.

A review of all existing plans and documents pertaining to the Nilan Dams reveals no stability analysis for either embankment. Inspection guidelines recommend a stability analysis be on record for dams such as Nilan East and North. There are no indications of unstable conditions with the exception of seepage in the natural ground downstream of the left portion of the north dam. Observed seepage in this area indicates a possible failure of the drains which could contribute to stability problems in the embankment. Observed seepage was free flowing and clear and there was no indication of piping. Also, the gravel blanket beneath the riprap on the upstream slope of both dams has been eroded away in some locations causing the riprap to slump and reduce protection against wave action.

RECOMMENDATIONS

Develop a downstream warning plan for use in the event of a structural failure, and immediately place this warning plan in action. Take corrective measures in areas where erosion and slumping has occurred and monitor the protective gravel blanket and the riprap on the upstream slope of both dams. Repair drains at the north dam and monitor the seepage. Provide drainage for the depression between the east dam and the county road. It is recommended that studies be conducted of each dam, including field exploration and laboratory testing of foundation and embankment soils, to evaluate embankment stability and modify the project as studies indicate. Continue to conduct periodic inspections of the project at five-year intervals by geotechnical engineers experienced in dam design and construction.

Prior to performing engineering studies and remedial construction, all work shall be coordinated with the Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

RODGER C.
FOSTER
3654 E

Rodger C. Foster

Rodger C. Foster
Professional Engineer

PERTINENT DATA
NILAN EAST DAM

1. GENERAL

Federal ID No.	MT-14
Owner	Montana State Department of Natural Resources and Conservation
Operator	Nilan Water Users Association
Date Constructed	1951
Purpose	Irrigation
Location	Section 20, T20N, R7W Principal Meridian; Latitude 47°28'24" Longitude 112°30'52"
County, State	Lewis and Clark County Montana
Watershed	Off-stream Storage Discharge to Elk Creek Drainage Basin
Size	Intermediate
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Nilan Reservoir, Montana

2. RESERVOIR

Surface Area at Spillway Crest	525 Acres
Drainage Area	3.55 square miles
Storage at Spillway Crest (elevation 4442.5 feet NGVD)	10,100 acre-feet
Storage at Dam Crest (elevation 4452.0 feet NGVD)	15,600 acre-feet
Surcharge Storage (Spillway to Crest of Dam)	5,500 acre-feet

3. SPILLWAY

Type	Unlined Channel with Concrete Control Weir
Bottom Width	72 feet
Crest Elevation	4442.5 feet NGVD
Capacity with Reservoir at Dam Crest 4452.0 feet NGVD	8620 cfs

PERTINENT DATA NILAN EAST DAM - Continued

4. OUTLET WORKS

Conduit	4-foot diameter, Cast-in-place Concrete Conduit
Conduit Length from Intake to Outlet	250 feet
Control Tower	Double Chambered Wet Well Located on the Upstream Edge of Dam Crest
Operating Gate (Downstream Chamber of Tower)	48-inch diameter Sluice Gate
Emergency Gate (Upstream Chamber of Tower)	48-inch by 48-inch Square Sluice Gate
Capacity with Reservoir at Dam Crest Elevation 4452.0 feet NGVD	385 cfs

5. DAM

Type	Rolled Earth
Length	1010 feet
Crest Breadth	Varies 20 to 23 feet
Crest Elevation	4452.0 feet NGVD
Hydraulic Height Crest to Toe	51 feet
Upstream Slope	1V on 2H to 1V on 1.8H
Downstream Slope	1V on 2H

PERTINENT DATA
NILAN NORTH DAM

1. GENERAL

Federal ID No.	MT-3206
Owner	Montana State Department of Natural Resources and Conservation
Operator	Nilan Water Users Association
Date Constructed	1951
Purpose	Irrigation
Location	Section 18, T20N, R7W Principal Meridian; Latitude 47°28'24" Longitude 112°30'52"
County, State	Lewis and Clark County Montana
Watershed	Off-stream Storage Discharge to Willow Creek Drainage Basin
Size	Intermediate
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Nilan Reservoir, Montana

2. RESERVOIR

Surface Area at Spillway Crest	525 Acres
Drainage Area	3.55 square miles
Storage at Spillway Crest (elevation 4442.5 feet NGVD)	10,100 acre-feet
Storage at Dam Crest (elevation 4452.0 feet NGVD)	15,600 acre-feet
Surcharge Storage (Spillway to Crest of Dam)	5,500 acre-feet

3. SPILLWAY

Spillway for Project is Located at East Dam.

4. OUTLET WORKS

Conduit	4-foot diameter, Cast-in-place Concrete Conduit
Conduit Length from Intake to Outlet	262 feet

PERTINENT DATA NILAN NORTH DAM - Continued

Control Tower	Double Chambered Wet Well Located on the Upstream Edge of Dam Crest
Operating Gate (Downstream Chamber of Tower)	48-inch diameter Sluice Gate
Emergency Gate (Upstream Chamber of Tower)	48-inch by 48-inch Square Sluice Gate
Capacity with Reservoir at Dam Crest Elevation 4452.0 feet NGVD	395 cfs

5. DAM

Type	Rolled Earth
Length	530 feet
Crest Breadth	Varies 20 to 22 feet
Crest Elevation	4452.0 feet NGVD
Hydraulic Height Crest to Toe	54 feet
Upstream Slope	1V on 2H
Downstream Slope	1V on 2H

Chapter 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Nilan Dams, owned by the State of Montana and operated by the Nilan Water Users Association.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federally owned dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigation and evaluation of existing dam conditions, so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is

(1) a limited investigation to assess the general safety condition of the dam.
(2) based upon an evaluation of the available data and a visual inspection.
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations, and analyses are necessary or warranted.
(4) not intended to include extensive explorations and analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases, the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigation outlined above are intended only to evaluate project safety and do not encompass in scope the engineering

required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam operator and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report are based on brief visual inspections of the project conducted on July 31, 1980 and October 9, 1980 and a detailed review of available construction plans. Inspection procedures and criteria are those established by the Recommended Guidelines for Safety Inspection of Dams (Reference 1).

Personnel present during the inspection included:

Larry Tegg	Dam Safety Engineer, State of Montana, Department of Natural Resources and Conservation
Robert Clark	Water Resource Engineer, State of Montana, DNR&C
Rodger Foster	Team Leader, Morrison-Maierle, Inc. Water Resource Engineer
Mike Kaczmarek	Engineering Geologist, Morrison-Maierle, Inc.
Phil Porrini	Water Resource Engineer, Morrison-Maierle, Inc.
Charles Gelsinger	Dam Tender, Nilan Water Users Association

An introductory meeting with Mr. Vic Krueger and Mr. Charles Gelsinger of the Water Users Association was held in Augusta prior to the inspection. Mr Gelsinger then accompanied the inspection team to the dam sites.

A second visit to the site was made on October 9, 1980 to inspect the outlet works of both dams at a time that would not interrupt the irrigation operations of the project. This inspection was conducted by Mr. Phil Porrini of M-M and Mr. Larry Tegg of DNR&C who were accompanied by Mr. Gelsinger, the dam tender.

Additional Morrison-Maierle personnel who contributed to the evaluation are:

Bill Keith	Structural Engineer
Ken Salo	Hydrologist/Hydraulics Engineer.

This report has been reviewed by the State of Montana, Department of Natural Resources and Conservation and the Nilan Water Users Association. The written comments received are included in the appendix.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

The Nilan Project is an off-stream storage project located between the Willow Creek and Elk Creek drainages approximately seven miles west of Augusta, Montana in Lewis and Clark County (Plate 1). The project, as shown on Plate 2, consists of Nilan Reservoir impounded by Nilan East Dam and Nilan North Dam, one inflow supply canal and two outflow distribution canals. The reservoir and dams are located on land deeded to the State of Montana for the project. The reservoir is used for irrigation water storage and does receive recreational use in the form of fishing and boating. The two dams impound approximately 15,600 acre-feet at the dam crest, elevation 4452.0 feet NGVD. All elevations used in this report are based on the assumed elevation 4400.75 feet NGVD at the invert of the east outlet pipe which corresponds to the project datum on the construction plans.

The Federal identification number for the Nilan East Dam is MT-14. This 51-foot high earth dam controls reservoir releases to the East Canal in the Elk Creek drainage. The spillway, located in a natural swale approximately 370 feet northwest of the west abutment of the east dam, also releases to the Elk Creek drainage. The spillway control section is a concrete retaining wall which functions as a low drop structure, 1.8 feet high, 72 feet long and 0.75 feet wide. Based on visual reconnaissance and engineering judgement, one ranch home, a county road and the Town of Augusta would be affected by a sudden breach of the east dam. On the basis of this information and in accordance with the recommended guidelines, the project size is classified as intermediate and the downstream hazard potential is high (Category 1).

The Federal identification number of the Nilan North Dam is MT-3206. This 54-foot high earth dam controls reservoir releases to the north canal in the Willow Creek drainage. Based on visual reconnaissance and engineering judgement, three ranch homes and two county roads would be affected by a sudden breach of the north dam. Water from a breach of the north dam would be received by the Willow Creek Reservoir located approximately 10 miles downstream.

Appurtenant to the north dam is a 1300-foot long dike which extends generally south from the south abutment along a low area in the topography. The dike is at the same elevation as the dam and varies in height from zero feet to eight feet with the same side slopes and crest width as the dam.

The project has a limited natural drainage area and is supplied by diversion from Smith Creek and Ford Creek as shown on Plate 2. A controlled low level outlet is located in each dam and the emergency spillway for the project is located near the east dam. The two outlet structures are identical and consist of a double chambered wet tower with an operational control gate and an emergency control gate. Outlet conduits are 4-foot diameter concrete conduits discharging to irrigation supply canals.

1.2.2 Regional Geology and Seismicity

The Nilan Reservoir and Dams are located in the foothills transition between the Northern Rocky Mountains and the Great Plains physiographic provinces of Fenneman (1931, Reference 2). More recent work, based more on the nature of the geologic characteristics of the region than on surface physiography, classifies the area including Nilan Reservoir as the Foothills province which is located between the Front Ranges to the west and the Interior Lowlands to the east (King, 1959, Reference 3). The Foothills and Front Range provinces comprise the disturbed belt along the eastern front of the northern Rocky Mountains.

The Foothills subdivision is the eastern part of the disturbed belt and comprises the area between the mountain front and the plain. Bedrocks exposed throughout the Foothills subdivision consist of Cretaceous strata which are predominantly shale, mudstone, and sandstone units. Bentonite beds and zones of limestone are commonly present in the thick shale units. The combined thickness of the Cretaceous rocks exposed in the Foothills province ranges from 4000 to 5500 feet (Mudge, 1972, Reference 4). The Nilan Reservoir is located in the eastern portion of the Foothills subdivision of the disturbed belt where geologic structure is characterized by broad open symmetrical folds and a few widely spaced high-angle thrust faults (Mudge and Earhart, 1978, Reference 5). West of the Nilan Reservoir area, the structure becomes closely spaced with abundant high-angle thrust faults.

The portion of the disturbed belt containing Nilan Reservoir was extensively glaciated by a piedmont glacier that proceeded eastward across the Foothills province from the mouth of the North Fork of the Sun River. The Sun River moraine as described by Alden (1932, Reference 6) reached a maximum width of 15 miles, north to south, and a length of 18 miles. Nilan Reservoir is situated on the southern margin of the Sun River moraine where it coalesces with moraine from a smaller glacier to the south in Smith Creek (Alden, 1932, Reference 6). The ground moraine and recessional moraines near Nilan Reservoir cover bedrock in most of the area and form a gently rolling to undulating plain bounded by arcuate low ridges of terminal moraine just east of the reservoir.

Nilan Reservoir and dams are located in seismic probability Zone 2 (Reference 1). Seismic probabilities used herein divide the United States into four seismic risk zones based on the record of the severity of ground shaking and the reasonable expectancy of earthquake damage. Seismic probability Zone 2 indicates that earthquakes with potential for moderate damage may occur. Zone 2 corresponds to a potential intensity of VII on the Modified Mercalli intensity scale of 1931. In accordance with

recommended guidelines (Reference 1), the hazard of seismic loading and resultant embankment shear failure is considered to be minimal in a seismic probability Zone 2 provided static stability conforms with accepted safety margins.

1.2.3 Site Geology

1.2.3(a) Nilan East Dam

The Nilan East Dam is situated on knob and kettle terrain on the east side of a large glacial kettle. The glacial kettle depression, formerly known as Beale Lake, was entirely inundated by the Nilan Storage Project. The knob and kettle topography of the area is underlain by glacial till consisting predominantly of clay and silty clay with the smaller amounts of intermixed gravels, cobbles, and boulders. Borings on the centerline of the Nilan East Dam (Reference 7) show the glacial till to range in thickness from a minimum of 30 feet to more than 40 feet.

A west to east flowing drainage dammed by the Nilan East Dam was a small melt water channel draining the Beale Lake depression. Two drill holes in the drainage penetrating to depths of 85 and 86 feet respectively, penetrated clayey gravel and pervious, water-bearing sand and gravel interbedded with lesser amounts of gravelly and sandy "yellow clay". The drainage course materials are interpreted to be kame terrace gravels, melt water outwash, and possibly some interbedded till.

1.2.3(b) Nilan North Dam

The Nilan North Dam is situated in a small natural water course incised into the rolling terrain of the glacial ground moraine northwest of the former Beale Lake. Surficial deposits at the site consist of a clayey glacial till which drill hole data indicates ranges from 10 to 55 feet thick. Drill hole data shows the flood plain of the water course at the site to be underlain by about 22 feet of fine-grained clayey alluvium containing stringers of interbedded sand and some gravel. Drill hole data show the bedrock below the glacial till and alluvium to consist of a hard, dry gray shale (Reference 7).

1.2.4 Design and Construction History

The Nilan Dam project was designed by the original State Water Conservation Board (SWCB) in cooperation with the Nilan Water Users Association in 1951. The State Water Conservation Board was the forerunner of the present Water Resources Division of the Montana Department of Natural Resources and Conservation. Engineering for the project was provided by SWCB engineers and the project was constructed in 1951 by Heald and Christler of Cody, Wyoming. The supply canal, the east canal and the north canal were constructed at the same time as the dam. The Florence Canal (Plate 2) was constructed in 1955. Seepage drains were installed in the north dam at some later date.

As-built drawings of the dams and outlet works, foundation boring logs of both dams (Plates 12 and 13), and previous inspection reports (Reference 8) are on file with the DNR&C and were reviewed for this inspection. Pertinent design drawings are reproduced as Plates 4 through 8 in this report. Construction control test information was not available for review.

Chapter 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1. Emergency Spillway

The emergency spillway for the Nilan project is an uncontrolled natural swale located approximately 320 feet northwest of the east dam (Plate 4 and Photos 16-18). The only structural modification made to the natural swale when it was developed as a spillway was the placement of a low concrete retaining wall or drop structure at the throat of the swale. The retaining wall is the control section for the spillway and is 72 feet long, 0.75 feet wide and drops 1.8 feet to the downstream ground line. The ground line against the upstream side of the retaining wall is at the top of the wall elevation 4442.5 feet (Plate 9). The approach to the spillway is a natural bay in the reservoir with an adverse slope of approximately 0.1 feet per foot from normal pool elevation to the crest of the retaining wall. Downstream of the drop section the swale follows a comparatively flat natural slope of approximately 0.01 feet per foot. The spillway discharges well below the east dam. The spillway is in good condition and there is no evidence of erosion at the retaining wall or in the downstream channel. Under high flow conditions some erosion would be expected in the channel but it would not threaten the stability of the east dam.

Collection of debris at the spillway is not a problem because the immediate drainage to the reservoir is grass land and there are essentially no trees to create debris.

The emergency spillway discharge rating (Plate 11) was developed using the HEC-2 Water Surface Profiles computer program (Reference 9) based on three channel sections (Plate 9) surveyed during the inspection and a Manning's "n" value of .032. The analysis indicates hydraulic control for the spillway is located at the retaining wall and that the maximum discharge capacity with the reservoir at the top of the dam, elevation 4452.0 feet NGVD, is 8620 cfs.

2.1.2 Outlet

Each dam of the Nilan project has a low level outlet works which controls releases to the respective irrigation canals. The outlet works are of the same basic design as indicated on Plates 5, 7 and 8, and differ slightly in the length and invert elevation of the outlet conduit. The outlet control works are located 21 feet upstream of the center line of the dam crest and consist of a double chambered wet tower with an operational control gate and an emergency control gate placed in series (see Plate 8). The emergency gate is located in the upstream chamber and is 48 inches square. A 48-inch diameter operational control gate is located in the downstream chamber at the entrance to the four-foot diameter outlet conduit. The operating controls for the gates are located in the gate house mounted over the wet tower. The gate stem for each gate extends up the chamber to a hand operated control. The intake structures and conduit upstream of

the control gates could not be inspected because of the reservoir level. Plans show the intake structure to be a rectangular concrete box with grated openings on the top, sides and end. The intake conduit is a four-foot diameter, cast-in-place, reinforced concrete conduit. The outlet conduit, downstream of the control tower, is also a four-foot diameter, cast-in-place, reinforced concrete conduit. The outlet structure consists of a concrete headwall with a trapezoidal concrete section which transitions to the irrigation canal. There are no energy dissipaters in the transition section.

A six-inch diameter air vent pipe provides air to the outlet conduit at each dam. The air vent is anchored to the outside of the downstream wall of the wet tower and branches at the conduit to provide two air supply points as shown on Plate 8. At the dam crest, the air intake is inverted 180 degrees to protect against plugging of the vent.

2.1.2(a) East Dam Outlet Works

The east outlet works (Plate 5) is similiar in design to the north outlet works with a 121-foot long inlet conduit and a 121-foot long outlet conduit. The invert elevation at the outlet is shown to be 4400.75 feet NGVD. The outlet conduit downstream of the control gate is in good condition with minor traces of seeping at six locations. Cracking is minimal and construction joints are smooth for the most part. No significant defects exist in the conduit. The outlet apron has some minor cracks and shows some spalling on the left wing wall (looking downstream). There is no seepage through the walls of the outlet apron section.

The operating gate tower is in good condition with the ladder, gate stem, operating gate, wedge blocks, and gate stem guides all in good condition. The emergency gate did not seal completely and leaked a small amount (jet of water) at the lower right side looking upstream. The conduit floor was uniform at the center and deposits of solid material (possibly grout) were noted at the edges.

The dam tender stated that the operating gate had never been opened more than six inches which produces a full flow in the outlet canal. Both gates were operated through their full range during the inspection. The discharge rating for the east outlet works at full pool elevation 4442.5 feet is approximately 340 cfs. The rating curve for the outlet is shown on Plate 11.

2.1.2(b) North Dam Outlet Works

As shown on the plans (Plate 7) the north intake conduit is 128 feet long and the outlet conduit is 126 feet long. The invert elevation at the outlet is shown to be 4397.25 feet NGVD. The outlet conduit downstream of the control gate was generally in good condition. Some minor seepage was observed from an 1/8 inch wide crack approximately five feet from the gate on the left side of the conduit (looking downstream). Additional seepage was observed around the entire conduit at a point approximately 25 feet downstream of the gate. Neither seep was significant and consisted mainly of surface moisture. Some construction joint offsets were noted but present no problems. Sediment is deposited at the outlet apron and in the first

fifty feet of the conduit floor but would be flushed out by high flows. Due to limited outlet channel capacity the operational gate is not opened more than one foot. Low discharges and flow velocities have caused little wear in the outlet in thirty years. Both gates were operated through their full range during the inspection.

The headwall above the outlet of the conduit is cracked and indications of minor seepage is evident. Seepage in the conduit and headwall has been noted in previous inspection reports and the conditions do not appear to have changed.

The operating tower was in good condition, and with the emergency gate closed, the operating gate was raised about two feet to allow drainage of the tower and inspection of the seals. The emergency gate was sealed and did not leak. The floor of the chamber was uniform at the center and irregular at the edges. Irregularities are probably excess grout left during construction.

The discharge rating for the north outlet works at full pool elevation 4442.5 feet is approximately 353 cfs. The rating curve for the outlet is shown on Plate 11.

2.1.3 Freeboard

The vertical distance between the low point on either dam and the reservoir level at the July 31, 1980 inspection was 11.4 feet. The spillway crest is 9.5 feet below the lowest point of the dams. The effective fetch for the east dam, which would receive the greatest wave action, is 0.78 miles. The maximum runup for wind generated waves at the east dam is estimated to be 4.5 feet.

Neither dam is overtopped during the PMF. The freeboard during the PMF would be 4.8 feet. The vertical distance between the top of the dam and the normal reservoir level is adequate to prevent waves overtopping the embankment.

2.2 HYDROLOGY, CLIMATOLOGY AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is continental in nature, characterized by warm summers and cold winters. Two climatological stations with good record are located in the vicinity of the Nilan basin. The Augusta station with 71 years of record is located seven miles east of the reservoir at an elevation of 4070.0 feet NGVD. Mean annual precipitation at Augusta is 14.4 inches with 26% falling in June, the heaviest precipitation month. A mean of 2.3 total inches of precipitation, 16% of the annual precipitation, falls during the winter months of December through March. Mean annual temperature at Augusta is 43.5°F with a mean June temperature of 57.8°F and a mean winter temperature from December through March of 26.5°F.

A second climatological station is located 13 miles northwest of the Nilan basin at Gibson Dam. The Gibson Dam station is at elevation 4590.0

feet NGVD and has 63 years of record. Mean annual precipitation at Gibson Dam is 19.3 inches with 22% falling in June, the heaviest precipitation month. A mean of 3.7 total inches of precipitation, 19% of the average annual precipitation, falls during the winter months of December through March. Mean annual temperature at Gibson Dam is 41.5°F with a mean June temperature of 54°F and a mean winter temperature from December through March of 26.2°F.

Mean annual precipitation in the Nilan basin is approximately 19 inches. Temperatures would be expected to compare with the Gibson Dam station which is 150 feet higher in elevation.

The drainage basin area for Nilan Reservoir is 3.55 square miles and is generally oval shaped (Plate 3). It is located in the rolling foothills of the eastern slopes of the Continental Divide on a small tributary to Willow Creek. The reservoir's natural drainage basin varies in elevation from 4452.0 feet to 4690.0 feet NGVD and its vegetation consists of short plain grasses. There are two small lakes located in the upper basin but the drainage area of the lakes is relatively small compared to the total reservoir and any routing effects would be insignificant. The uppermost lake is approximately 15 feet higher in elevation than the main reservoir.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 525 acres and a storage volume of 10,100 acre-feet at the emergency spillway crest elevation 4442.5 feet NGVD. Approximately 5,500 acre-feet of surcharge storage is available in the reservoir between the emergency spillway crest and the crest of either dam. The emergency spillway discharge with the reservoir at the dam crest elevation 4452.0 feet is estimated to be 8620 cfs. A discharge rating curve for the spillway is presented on Plate 11.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir.

The probable maximum precipitation (PMP) was developed using procedures outlined in the "Interim All-Season Probable Maximum Precipitation Estimates, Missouri River Drainage West of the 105th Meridian," published by the Hydrometeorological branch of National Oceanic and Atmospheric Administration (NOAA), January 1, 1980 (Reference 10). The PMP produces 20.0 inches of rain in a 24-hour period and 25.0 inches of rain in 72-hours. A minimum loss rate of 0.15 inches per hour was assumed to represent the hydrologic class B soils in the basin and minimum infiltration conditions due to saturated ground.

Using the assumed loss rates, the HEC-1 (Reference 12) analysis indicates that no runoff would be produced in the last 48 hours of the storm. Therefore, the first 24-hour period of the storm was used in the analysis.

Nilan Reservoir is supplied by diversions from Ford and Smith Creeks via the main supply canal with a capacity of 300 cfs which was assumed as a base inflow into the reservoir.

The 3.55 square mile basin contains 1.04 square miles of reservoir water surface at normal pool and 2.51 square miles of land area. A triangular unit hydrograph for a 7-minute rainfall duration was developed for the land area using procedures contained in Design of Small Dams (Reference 11). The Kirpich equation was used to determine the time of concentration which equaled 0.5 hours. The Soil Conservation Service method of developing a curvilinear fit of the triangular unit hydrograph was used. The hydrograph was divided into 7-minute increments and the PMP was applied to the unit hydrograph by means of the computer program HEC-1 (Reference 12). This estimate of the PMP produced a flood with a peak flow of 24,800 cfs and a volume of 3430 acre-feet with the base flow.

2.2.4 Flood Routing

Routing the probable maximum flood through Nilan Reservoir was performed using the computer program HEC-1 Flood Hydrograph Package (Reference 12). The reservoir was assumed to be at the emergency spillway elevation (4442.5 feet NGVD) at the beginning of the PMF. The routing was performed assuming the outlet works of both dams were closed and only the emergency spillway was available for discharge. This analysis indicates that during the PMF the reservoir would rise to elevation 4447.2 feet NGVD and the dam would not be overtopped.

2.3 GEOTECHNICAL EVALUATION

2.3.1(a) East Dam

The Nilan East Dam is about 51 feet high from the outlet structure discharge invert to the embankment crest (Plates 4 and 5). The total length of the crest is about 1010 feet and the crest width ranges from the plan width of 20 feet to as much as 23 feet where road surfacing gravel side cast over the faces of the dam during periodic grading of the crest road over the years has widened the crest. The axis of the dam has an angle point about 700 feet from the right abutment where the axis direction of S 1° 45' W changes to S 60° 45' E.

The downstream slope of the dam slopes at 1V on 2H as per the plans. The portion of the upstream face exposed during the July 3, 1980 inspection ranges in slope from 1V on 2H to about 1V on 1.8H. The steeper slopes correspond to wider crest sections and are apparently related to the build up of side cast material on the dam face. The plans call for an upstream slope of 1V on 3H for the embankment about 10 feet vertically below the crest elevation. The 1V on 3H slope was inundated at the time of the inspection. The measured dimensions of the east dam compare closely to the plans with the exceptions noted.

The source of borrow for the Nilan East Dam embankment was the sandy, gravelly clay glacial till from which the dam was constructed as a homogenous embankment. The downstream face is not covered by riprap or a protective

shell zone. There is no evidence of slope failure, soil creep, or accelerated erosion in the downstream face. A few scattered rodent burrows are present in the uppermost three to four feet of downstream face below the crest elevation. The downstream face is sparsely to moderately vegetated with grass and weeds.

The upstream face of the embankment is covered with roughly 24 inches of unclassified riprap placed over 12 inches of sand and gravel bedding. The riprap consists of hard sandstone and dolomitic limestone blocks ranging in size from cobbles to blocks four feet in maximum dimension. The riprap shows no evidence of deterioration due to chemical or mechanical weathering. A small slump is present in the face of the riprap at about station 3+75. The top of the slump scarp is about seven vertical feet below the dam crest. Vertical displacement in the slump is about three feet so that the top surface of the slump is about 10 vertical feet below the dam crest. The surface length of the slump from scarp to toe is about four feet and the toe of the slump failure cuts the dam face 12 feet below the crest at the change in slope from 1V on 2H to 1V on 3H.

Careful inspection of the slump shows the cause of the failure in the riprap to be wave erosion of the bedding underlying the riprap. The riprap is very open graded and bedding material is visible through the interstices of the riprap in many places. Erosion of the bedding sand and gravel caused the riprap to progressively settle into the erosion cavity. Numerous irregularities are evident in the slope of the riprap face. The irregularities in slope suggest that bedding erosion may have taken place behind the riprap over most of the face of the dam from station 3+00 to 10+00. Wave erosion near station 0+00 has removed both natural ground and riprap bedding and undermined the toe of the riprap at the abutment.

2.3.2(a) East Dam - Foundation Conditions, Seepage, and Drainage

The foundation of the East Nilan Dam consists of dense glacial till that test borings (Reference 7) show to have a minimum thickness of 30 feet. Foundation materials in the vicinity of the outlet conduit from about station 5+20 to 6+60 consist of five to 12 feet of "yellow clay and gravel" below which are glaciofluvial sediments consisting principally of sand and gravel. No instrumentation was installed in the embankment or appurtenant structures.

Construction drawings (Plate 4) show homogenous dam with a cutoff trench under the upstream portion of the dam. The centerline of the cutoff trench is 35 feet upstream from the centerline of the embankment. The cutoff trench is 10 feet deep, 10 feet wide at the base, and has 1V on 1.5H side slopes. Careful examination of the dam did not reveal any evidence of seepage in the dam embankment, foundation, or abutments. The pool level at the July 31, 1980 inspection was 4441.1 feet NGVD. Neither the construction plans nor the field inspection reveal drainage systems in the east dam. A small undrained depression between stations 1+00 and 3+00 is blocked by the county road fill. Ponded water present in the depression obscured any seepage that may have been present at that location. A State Water

Conservation Board inspection report dated May 4, 1953 indicates that a drain is present under the road fill and was blocked at the time of that inspection with resultant ponding of water in the depression.

2.3.3(a) East Dam Stability

The July 31, 1980 field inspection of the Nilan East Dam did not reveal any evidence of embankment failure or potential instability and the general geometry and configuration of the embankment appears to be in conformance with recommended guidelines for stable rolled earth embankments.

Inspection guidelines recommend a seepage and stability analysis be on record for dams such as Nilan and that the computed safety factor for steady seepage conditions be not less than 1.5. A review of all existing plans and documents pertaining to the east dam revealed no design seepage or stability analysis for the embankment. Discussion of embankment stability is therefore limited to observed conditions.

2.3.1(b) North Dam

The North Nilan Dam is about 1830 feet long (Plate 6). Approximately 1300 feet of the dam, as measured from the right abutment, consists of low embankment no more than eight 8 feet high. The slopes on the low embankment are 1V on 2H and the crest width is about 20 feet. Natural ground rises to the crest elevation of the low embankment between 750 and 770 feet from the right abutment where the low embankment is continuous with 20 feet of natural ground on the crest grade. The principal embankment of the Nilan North Dam begins about 1300 feet from the right abutment where it is continuous with the low embankment.

The field measurements reveal a depression four to six feet wide that extends across the dam crest at the outlet control tower. The depression ranges from 0.3 feet deep at the crest centerline to 0.7 feet deep at the crest shoulders. The depression appears to be the result of differential settlement due to consolidation of fill over the outlet conduit. There is no evidence of surface erosion or other disturbance to explain the presence of the depression.

The downstream face of the embankment slopes at 1V on 2H as per the plans. The 11 feet of the upstream slope exposed above water during the July 31, 1980 field inspection is covered with riprap up to four to five feet in mean dimension which gives it an irregular appearance; however, the average slope appears to be 1V on 2H. The plans call for a 1V on 2H upstream slope on the uppermost 10 feet of embankment and 1V on 3H for the remaining embankment.

The Nilan North Dam is a homogenous embankment consisting of slightly gravelly, silty clay obtained from the glacial till deposits at the damsite. Construction plans (Plate 6) indicate the presence of a cutoff trench along the full length of the embankment. The upstream face is protected with unclassified riprap resting on 12 inches of sand and gravel bedding. The riprap consists chiefly of limestone and dolomitic limestone and lesser amounts of hard sandstone all ranging in size from six to 10-inch fragments

to boulders four to five feet in mean size. The riprap does not show signs of chemical or mechanical deterioration or displacement due to erosion, settlement or slumping.

Wave erosion is encroaching into natural ground in the shoreline area below the embankment toe about seven to eight feet upstream from the embankment in the area from 1200 to 1350 feet from the right abutment. At about 1250 feet from the right abutment, wave erosion of the natural ground has undermined the toe of the embankment for a distance of about six feet into the embankment material and riprap and embankment fill have collapsed into the erosion cavity. Riprap that has collapsed into the wave-eroded cavity is presently providing partial protection from continued wave erosion.

The downstream slope of the embankment is regular and exhibits no evidence of erosion, slope failure, sloughing, or animal burrows. Vegetation consists of sparse grass, clover, and weeds with 25 to 50 percent of the ground surface unvegetated. Animal burrows are not present in the downstream face; however, a few cow paths traverse the face. A crack about 0.25 to 0.5 inches wide in the shoulder of the downstream crest parallels the downstream face. The crack is discontinuous and is six to eight inches deep. There is no evidence of displacement or shear along the crack which is interpreted to be the result of dessication of the expansive clays in the embankment fill.

2.3.2(b) North Dam - Foundation Conditions, Seepage, and Drainage

The foundation of the Nilan North Dam consists of dense glacial till 10 to 55 feet thick over Cretaceous clay shale except at the outlet conduit where fine-grained clayey alluvium about 20 feet thick is present in a small portion of the foundation. The original north dam cross sections drawn in 1951 by Brittain and Owens (not shown in this report) call for a cutoff trench 10 feet deep and 10 feet wide at the base with 1V on 1.5H side slopes and centered 35 feet upstream from the crest centerline. Careful examination of the embankment and abutments did not reveal seepage or a wetting front. No instrumentation was installed in the embankment or appurtenant structures.

Considerable seepage was present on the surface of the alluvial foundation materials about 20 feet downstream from the embankment toe on the left side of the outlet canal. Dense vegetation above the outlet conduit indicated the presence of seepage along the outside of the conduit and several cracks in the downstream face of the wing walls were weeping (Photo 32).

The existing plans and documentation regarding the Nilan Dams do not show or describe the nature and location of foundation drains at the north dam. A State Water Conservation Board inspection report by R.H. Fiefield dated May 18, 1953 states "Note: Seepage 16' below W.S. reservoir, 26' from the top of dam," and "Some seepage right side below dam. Should extend present drain ± 25' [and] construct additional drain on flat at base of hill." The foregoing 1953 inspection report indicates that toe drains were included in the foundation of the north dam during the original 1951 construction. The extent and nature of subsequent modifications to the drains, if any, is not known. Later inspections indicate that portions of the drains were exposed by erosion up until 1973. A 1974 report indicates the exposed drain pipes were reinstalled(?) and backfilled.

At the time of the July 31, 1980 inspection, two drains were observed discharging water into the outlet canal (Plate 14). The outfall on the right drain was located 40 feet downstream from the outlet conduit headwall and 6.64 feet above the outlet conduit invert. The outfall on the left drain was an estimated 50 to 60 feet downstream from the outlet conduit headwall and 3.94 feet above the outlet conduit invert. The right drain was discharging a measured 48 gpm and the left drain was discharging 8.6 gpm with additional unmeasured flow discharging along the outside of the drain pipe. Both pipes were six-inch diameter concrete pipe. Seepage from both drains was clear. Clear seepage was discharging from the left overbank area of the outlet canal above the left drain 12.62 feet above the outlet conduit invert and 8.68 feet above the invert of the drain outfall. The reservoir water surface at the time of the inspection was 42.61 feet above the outlet conduit invert.

The left toe drain pipe sloped steeply into the outlet canal. The left canal bank from the end of the outlet apron wingwall to a point five or 10 feet downstream from the left drain pipe had slumped with a vertical displacement ranging from two to three feet along the slump scarp. The slump appeared to have displaced the left drain pipe and any drain bedding around the pipe. Displacement may have offset the entire drain, blocking the continuity of the drain and causing the reduced flow from the left drain and failure of the drain to relieve seepage pressure. The failure of the drain to function properly is the probable cause of seepage on the alluvial foundation in the overbank area on the left side of the outlet canal above the drain. The presence of seepage on the overbank area at the toe of the embankment indicates undesirable foundation seepage pressures that should be relieved by the drain.

The cause of the slump that displaced the left foundation drain was probably a combination of canal wall erosion in the outlet canal and oversteepening of the canal wall due to erosion or canal excavation to remove sediment. Other slumps are present in the canal walls downstream from the dam and do not appear to be related to seepage pressures, but are in areas of oversteepened canal banks.

2.3.3(b) North Dam Stability

A stability analysis has not been performed for the Nilan North Dam embankment and the available information is not adequate to permit evaluation of stability. Because of the presence and evidence for seepage and settlement over the outlet conduit, a stability and seepage investigation is needed.

2.4 PROJECT OPERATION AND MAINTENANCE

The project is owned by the State of Montana and operated by the Nilan Water Users Association. Information on operations and maintenance was obtained from discussions with Mr. Charles Gelsinger of the Water Users Association and Mr. Larry Tegg of the DNR&C.

2.4.1 Dams

There is no periodic maintenance plan for the dams. The DNR&C conducted inspections of the dams in 1953, 1965, 1967, 1972, 1973, 1974, 1975 and 1979. Minor deficiencies in the dams which require continued monitoring are noted in the inspection reports. Correction of the seepage problems at the toe of the north dam and wave erosion problems noted in previous inspection reports have not been made. The gate controls were found to be in good condition and well maintained. The road across the east dam is maintained by the county and is routinely graded and gravelled. A small clump of trees is growing in natural ground incorporated into the upstream slope of the east dam.

2.4.2 Reservoir

Nilan Reservoir is an off-stream irrigation storage project supplied by diversions from Ford and Smith Creeks (Plate 2). Diversions are made to fill the reservoir by spring prior to the irrigation season. Releases are made to the North and East Canals from the respective outlets to service irrigators. Gates are operated at a fraction of their capacity in order to maintain discharges within the canal capacities. By late September the outlets are closed for the season. The capacity of the reservoir supply canal is listed as 300 cfs from Ford Creek. The canal passes through a low divide to the Nilan drainage at an elevation high enough above Ford Creek to prohibit inadvertent overflow from the creek to the reservoir even during a PMF in that drainage.

2.4.3 Warning Plan

There is no formal warning plan in use in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dams, supplemented by analysis of the project according to the recommended guidelines, resulted in the following findings.

3.1.1(a) East Dam Size, Hazard Classification and Safety Evaluation

In accordance with the recommended guidelines (Reference 1), the east dam is classified as intermediate in size and the downstream hazard potential is high (Category 1). The hazard classification is due to the potential for loss of life at one ranch home and economic loss and damage to county roads and the town of Augusta. The recommended spillway design flood for this dam and the total project is the full PMF. Because the project can handle the PMF without overtopping the Nilan East Dam, the east dam conforms with the flood handling requirements of inspection guidelines.

The field inspection of the east dam did not reveal any embankment failure or potential instability and the general appearance of the embankment seems to be in conformance with recommended design criteria. However, the inspection guidelines recommend a stability analysis be on record for dams such as Nilan and currently this stability analysis is not available due to insufficient information.

3.1.2(a) East Dam Embankment

A visual inspection of Nilan East Dam revealed no longitudinal or transverse cracking. The downstream slope was uniform with no irregularities and was free of trees and bushes. The upstream slope is protected by riprap. A small slump exists in the riprap near the angle point of the dam which is the result of wave action eroding away the gravel blanket undermining the riprap. Irregularities in the riprap on the upstream slope suggest this condition exists over much of the length of the east dam. A small clump of trees exists in a portion of natural ground adjacent to the upstream slope of the embankment in such a position that root zones could extend beneath the embankment. No seepage was observed downstream of the dam. However, a small undrained depression which ponds water is located between the dam embankment near the left abutment and the county roadfill. Ponded water in the depression could obscure seepage which may be present at that location.

3.1.3(a) East Dam Spillway and Reservoir Capacity

The reservoir has a surface area of 525 acres and a storage volume of 10,100 acre-feet at the emergency spillway crest elevation 4442.5 feet NGVD. Approximately 5,500 acre-feet of surcharge storage is available in the reservoir between the emergency spillway crest and the crest of either dam.

The emergency spillway, located in a natural swale near the east dam, is the only spillway for the project. The spillway discharge capacity with the reservoir at the dam crest elevation 4452.0 feet is 8620 cfs.

3.1.4(a) East Dam Outlet Works

The outlet conduit, tower and gates were inspected and found to be in good condition.

3.1.1(b) North Dam Size, Hazard Classification and Safety Evaluation

In accordance with the recommended guidelines (Reference 1), the north dam is classified as intermediate in size and the downstream hazard potential is high (Category 1). The hazard classification is due to the potential for loss of life at three ranch homes and economic loss and damage to county roads, farm land and the Willow Creek Reservoir. The recommended spillway design flood for this dam is the full PMF.

Because the project can handle the PMF without overtopping the Nilan North Dam, the north dam conforms with the flood handling requirements of inspection guidelines.

Insufficient information is currently available to permit an evaluation of embankment stability and due to the presence and evidence for seepage and settlement over the outlet conduit, such an investigation is needed.

3.1.2(b) North Dam Embankment

A visual inspection of Nilan North Dam embankment revealed no significant longitudinal or transverse cracking. Observations were made of a depression across the dam's crest which appears to be the result of differential settlement due to consolidation of fill over the outlet conduit. This depression ranges from 0.3 feet to 0.7 feet deep and extends across the dam crest four to six feet wide. The downstream slope was uniform with no irregularities and was free of trees and bushes. The upstream slope of the embankment is protected by riprap which is in good condition. Near the right abutment where the dam embankment joins the dike, wave erosion of the natural ground has undermined protective riprap on the embankment. The riprap is providing partial protection in this area but a steepened scarp does exist.

No seepage was observed in the embankment. However, considerable seepage was observed about 20 feet downstream of the toe on the left side of the outlet canal. A drain had been placed in this area and was discharging clear water at a rate of nine gpm. Movement in the seep area has apparently displaced the left drain reducing its effectiveness. Clear water was observed flowing into the canal from around the outside of the drain. The drain from the right bank was functioning well and was discharging approximately 48 gpm of clear water. There are no indications of seepage in the right downstream bank area. Seepage has been reported at the headwall and wingwalls of the outlet structure indicating the presence of seepage along the outside of the conduit.

There is no stability analysis for the north dam on file. The presence of seepage in the left overbank area indicates undesirable foundation seepage pressures possibly affecting stability.

3.1.3(b) Spillway and Reservoir Capacity

The spillway and reservoir discussion for the Nilan project is presented in Section 3.1.3(a).

3.1.4(b) North Dam Outlet Works

The outlet conduit, tower and gates at the north dam were inspected and found to be in good condition. Small cracks were observed in the conduit and there was evidence of scale build-up but no flowing water. The gates were operated through their entire range.

3.1.5 Operations and Maintenance

The project is operated to regulate irrigation releases during the irrigation season and the remainder of the year the gates remain closed. Inflow to the reservoir is controlled by a diversion canal from Ford Creek. Inflow is stopped when the desired pool elevation is attained. The DNR&C inspects the project regularly and the dams are visited almost daily by the dam tender during the irrigation season. There is no formal downstream warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

The intent of report recommendations is to improve project safety and to identify maintenance and repair needs of the project.

1. Develop, implement and periodically test an emergency warning plan in the event of an impending structural failure.

2. Evaluate the seepage and piezometric conditions by installing and monitoring piezometers at the east dam and the north dam. Particular attention should be given to the seepage condition evident in the vicinity of the outlet pipe and the left toe drain at the north dam. Repair and replace drains on the north dam or provide additional drainage as determined necessary. This work should be done under the guidance of a qualified, experienced geotechnical engineer.

3. Conduct and place on file a stability analysis of each dam embankment. This analysis should be based on actual measured piezometric conditions and shear strengths developed from exploration, sampling and testing. It is recommended that this analysis be performed by qualified geotechnical engineers.

4. Provide drainage from the depression between the east dam embankment and the county road and inspect the area for seepage.

5. Investigate the erosion condition of the gravel blanket on the upstream slopes of both dams and take corrective measures as indicated.

6. Conduct continued inspections of the Nilan East and North Dams at least once every five years by engineers experienced in dam design and construction.

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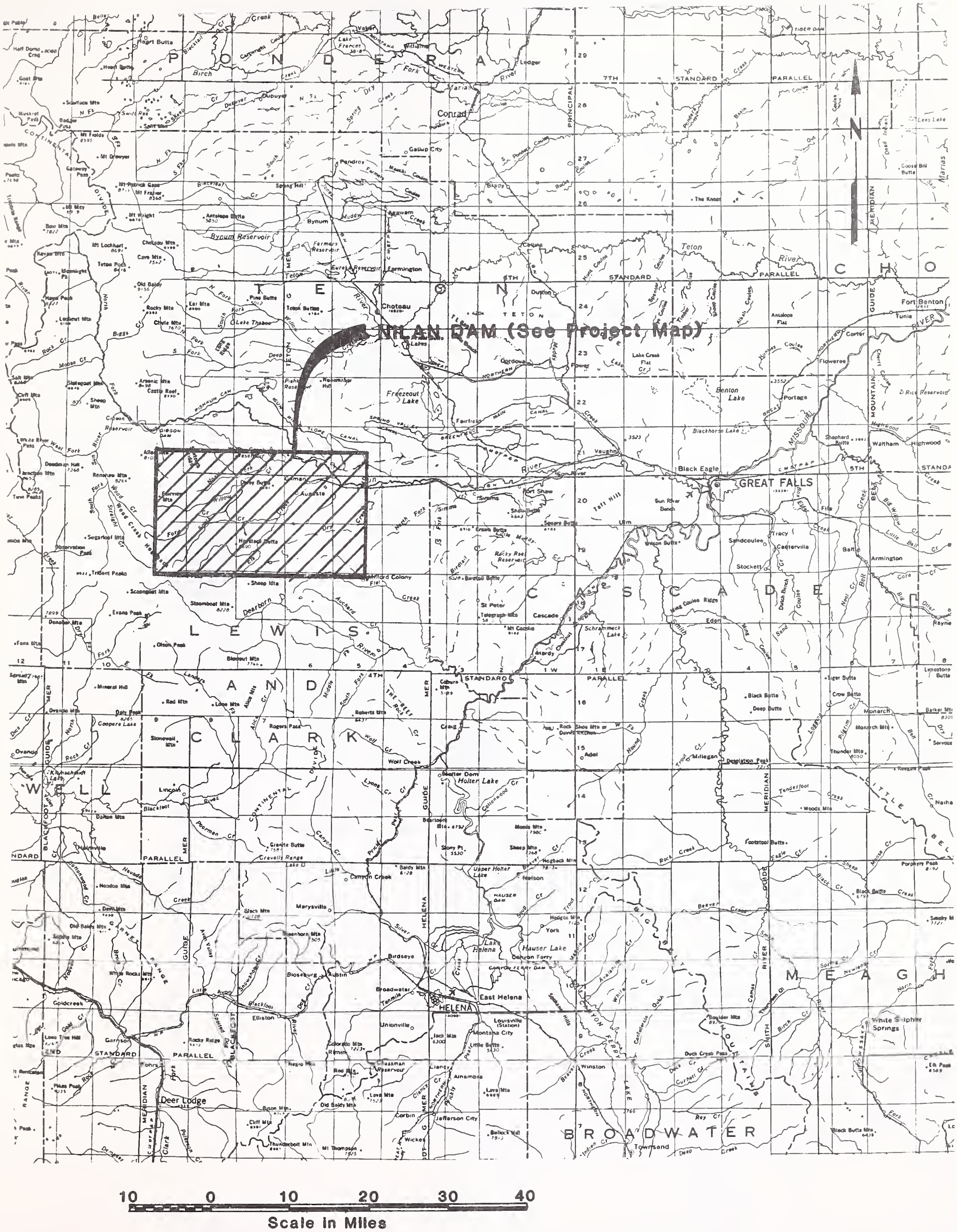
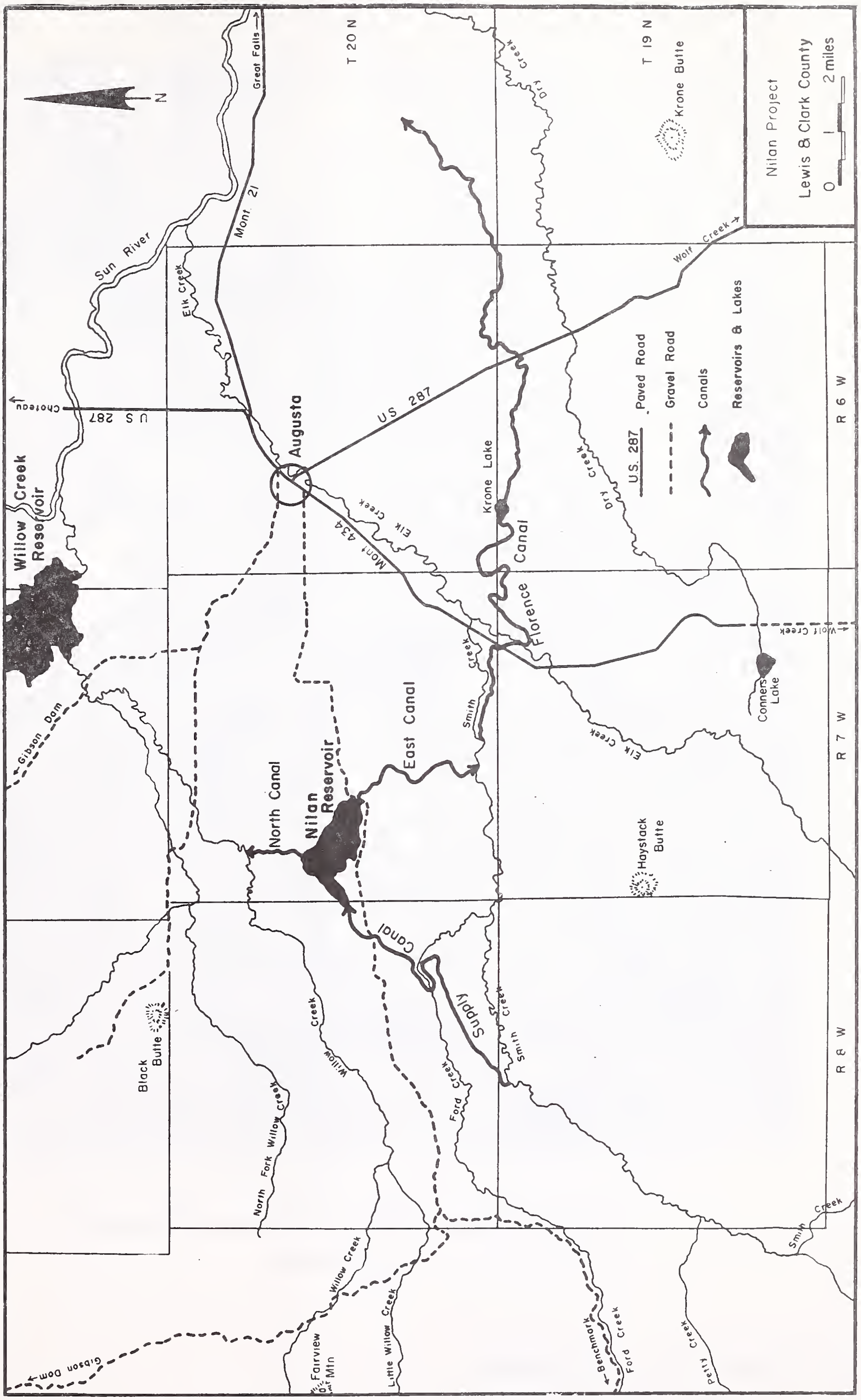


VICINITY MAP

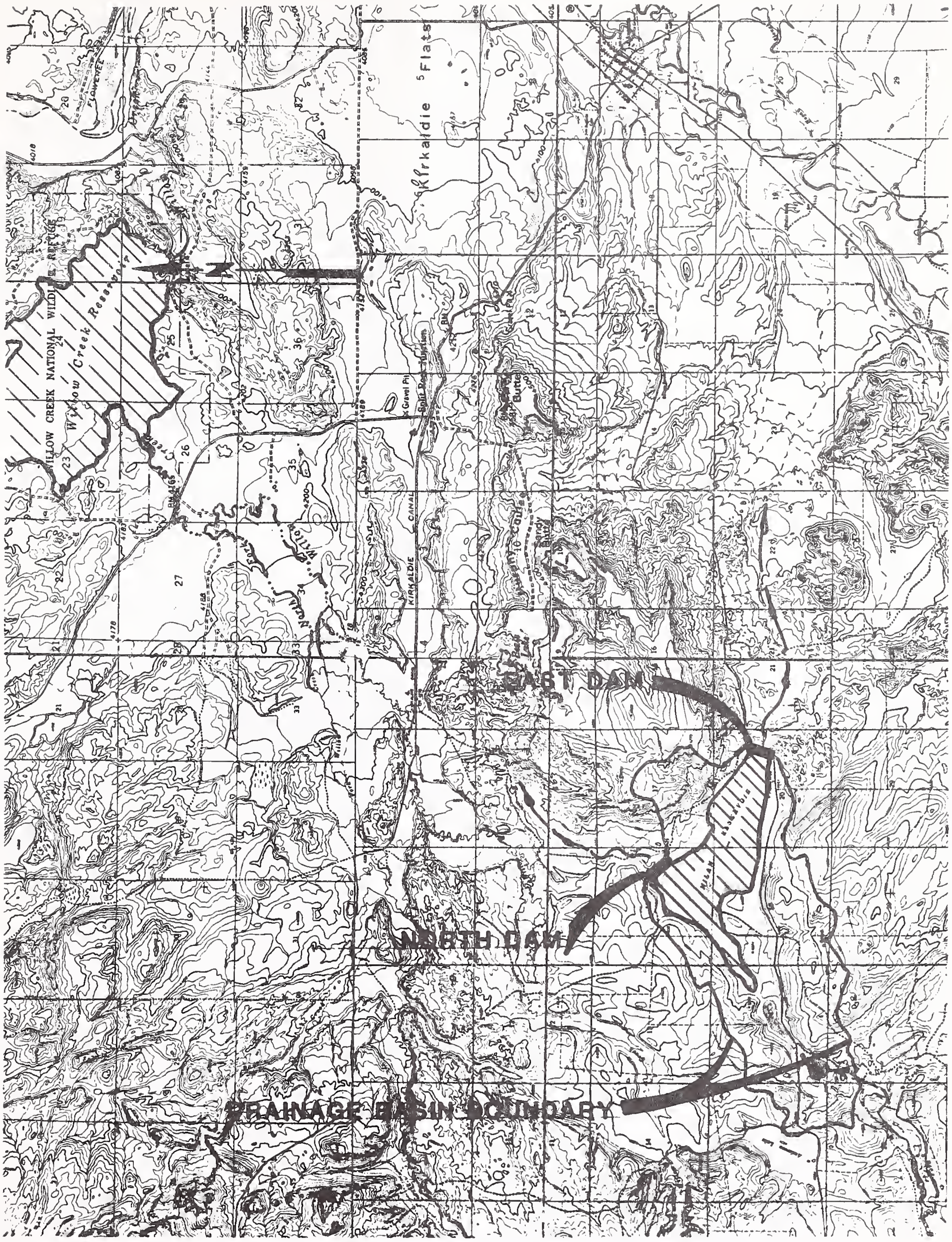
PLATE 1



Source: STATE WATER CONSERVATION PROJECTS
Water Resources Division
Montana Department of Natural Resources & Conservation

NILAN PROJECT MAP

PLATE 2

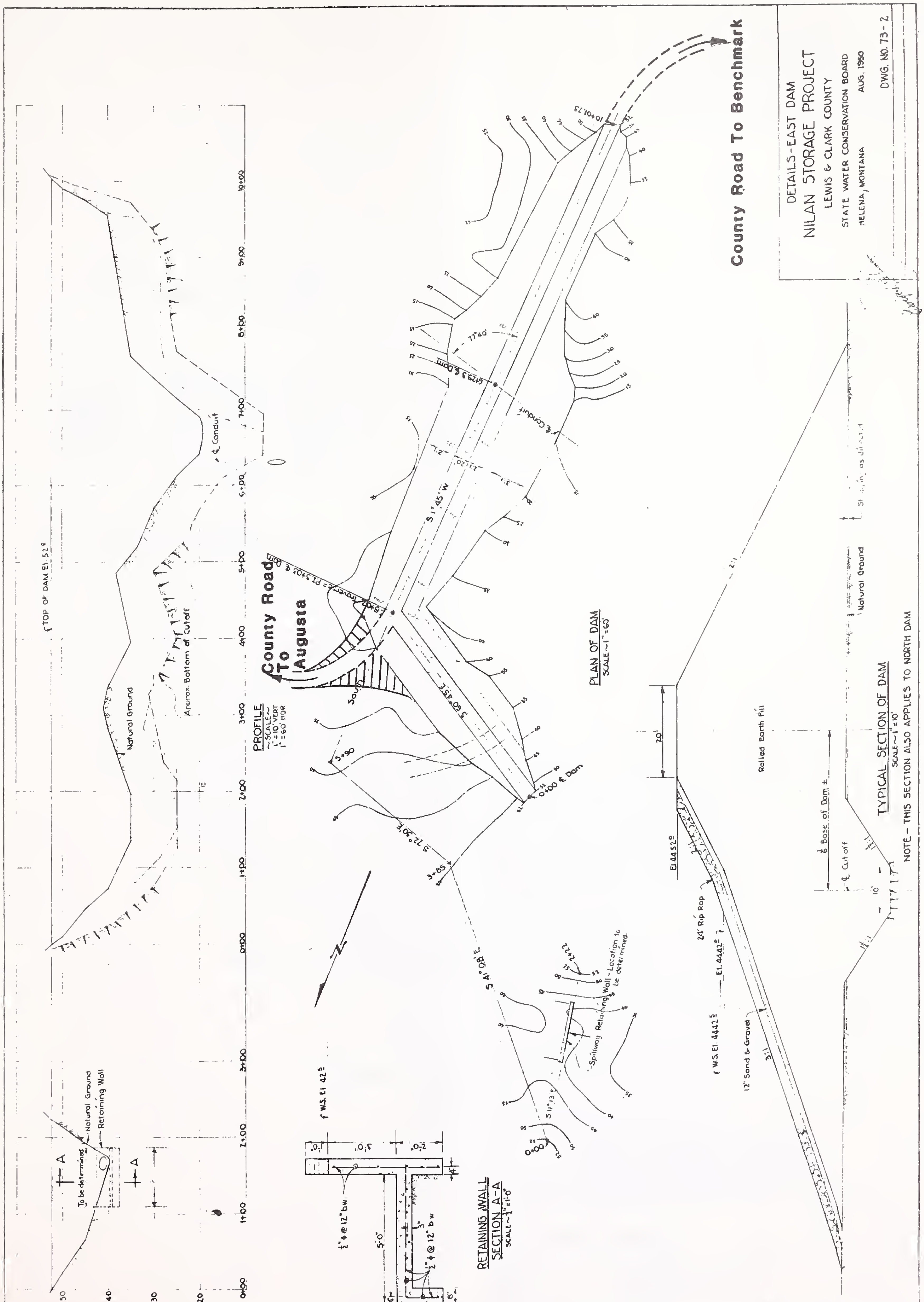


Source of Base: U.S.G.S. Quadrangle Maps

Scale in Miles

NILAN DAM AND RESERVOIR
SITE MAP

PLATE 3

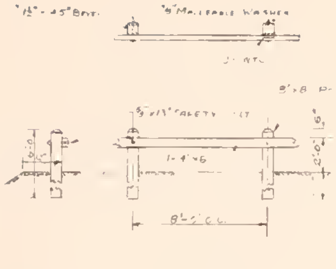


EAST DAM PLAN AND PROFILE

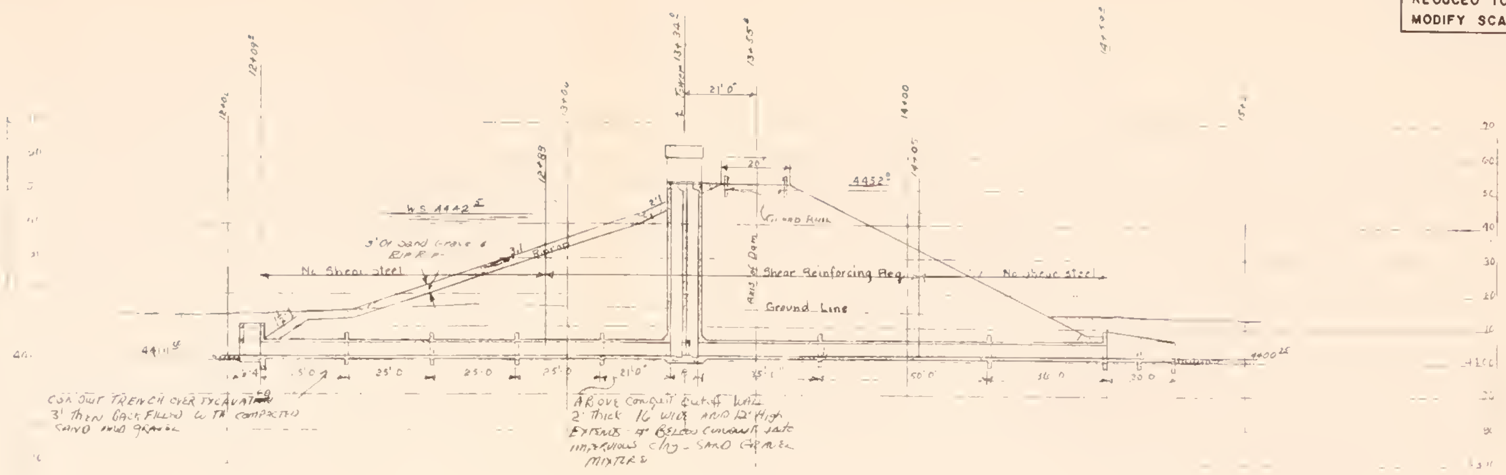
PLATE 4

"NOTICE"

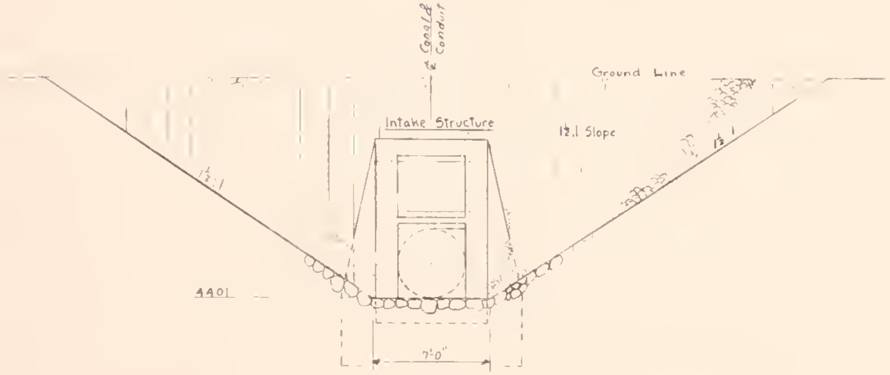
THIS SET OF PLANS HAS BEEN REDUCED TO ONE-HALF SIZE. MODIFY SCALES ACCORDINGLY.



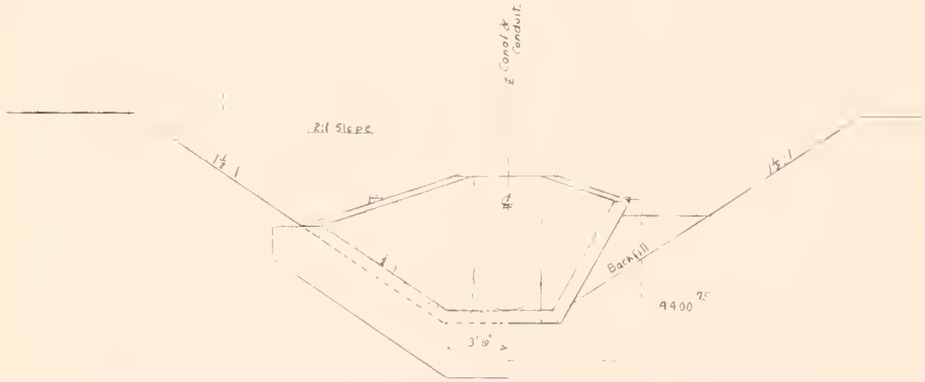
DETAILS OF WOOD GUARD RAIL
Scale - ½" = 1'


12+09
12+00
13+00
12+89
Tower 13+34
13+55
14+00
14+05
14+70
15+
21'0"
20'
4452°
W.S. 4442
3' of Sand Gravel & Rip Rap
3:1
2:1
No Shear steel
Shear Reinforcing Req.
No shear steel
Axis of Dam
Guard Rail
Ground Line
4411
4400.25
5'0"
25'0"
25'0"
25'0"
21'0"
35'
50'0"
30'0"
Cut out trench over excavation 3' then backfill with compacted sand and gravel
Above conduit cutoff wall 2' thick 16' wide and 12' high extends 4' below conduit. Use impervious clay - sand gravel mixture

PROFILE ALONG CONDUIT - EAST DAM
Scale 1" = 20 ft



SECTION SHOWING GRADING AT INTAKE
Scale ¼" = 1 ft



HALF SECTION AT END OF OUTLET STRUCTURE HALF SECTION MIDWAY OF STRUCTURE
SHOWING GRADING AT OUTLET
Scale ¼" = 1 ft

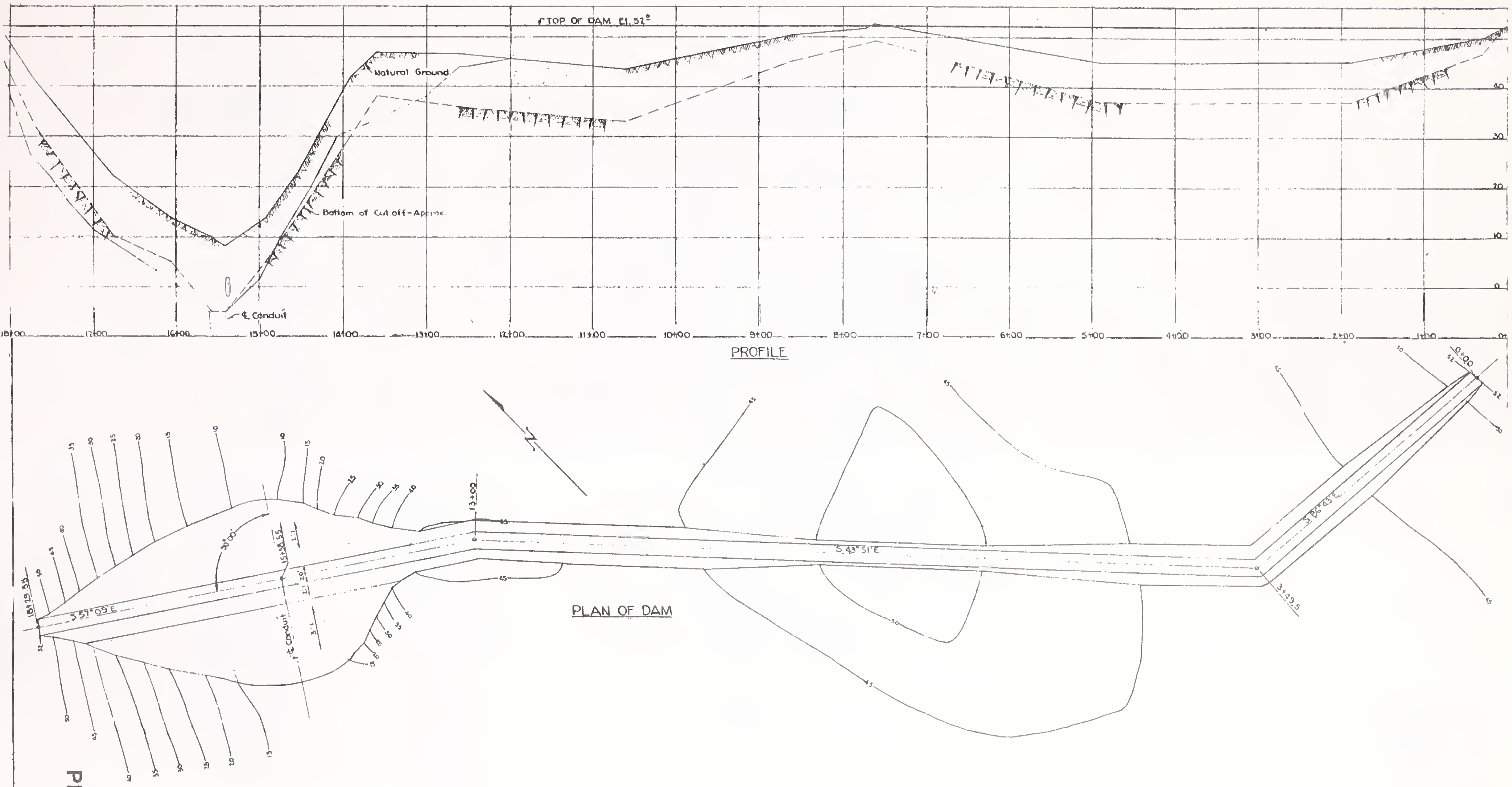
References:
North Dam Intake Structure Dwg No [illegible]
North Dam Control Tower " 5
North Dam Conduit & Outlet Structure " " 3

Conduit and Control Tower Details similar to North Dam.
Intake and Outlet Structures same as for North Dam except for Elevation.

CONTROL WORKS - EAST DAM
NILAN STORAGE PROJECT
LEWIS & CLARK COUNTY
STATE WATER CONSERVATION BOARD

Helena, Montana Dec. 1942
Scale as Shown
Dwg. No. 73 - 4

PLATE 5



Approx. 35% Reduction

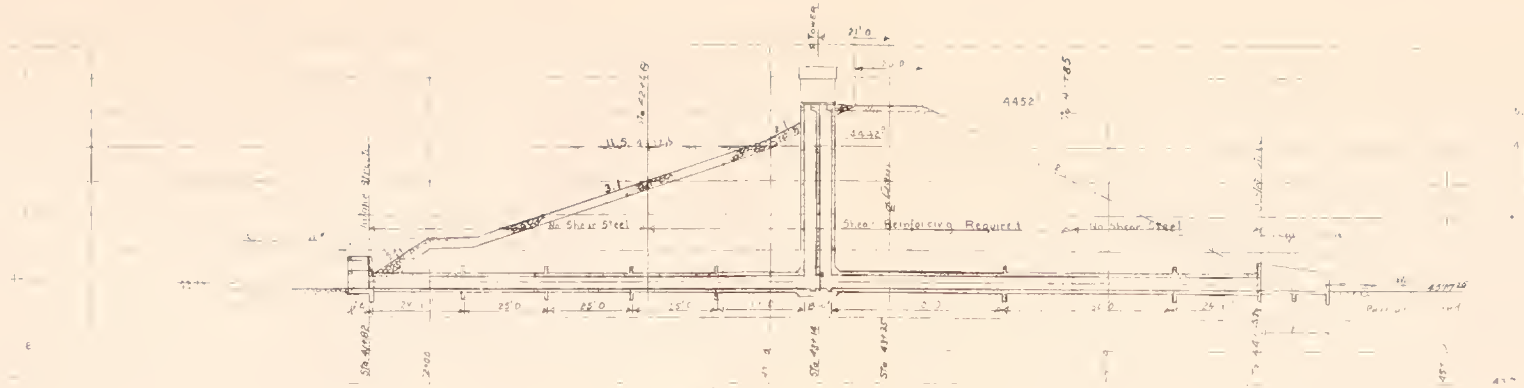
DETAILS-NORTH DAM
NILAN STORAGE PROJECT
LEWIS & CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA
AUG. 1950
DWG. NO. 73-1

NOTE:-
See Dwg No. 73-2 for Section of Dam
North & East Dams are similar

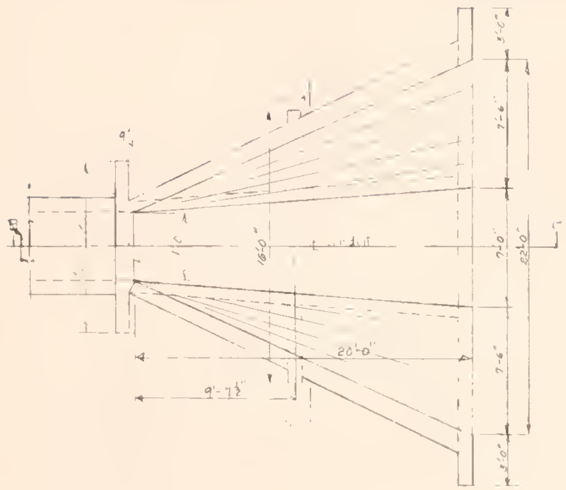
NORTH DAM
PLAN AND PROFILE

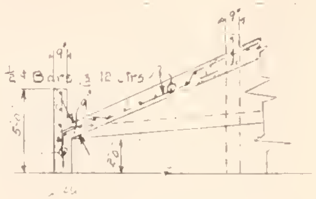
PLATE 6

"NOTICE"
THIS SET OF PLANS HAS BEEN
REDUCED TO ONE-HALF SIZE.
MODIFY SCALES ACCORDINGLY

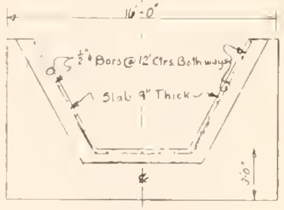


PROFILE [illegible] CONDUIT
Scale 1"=20ft



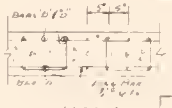


SECTION C-C

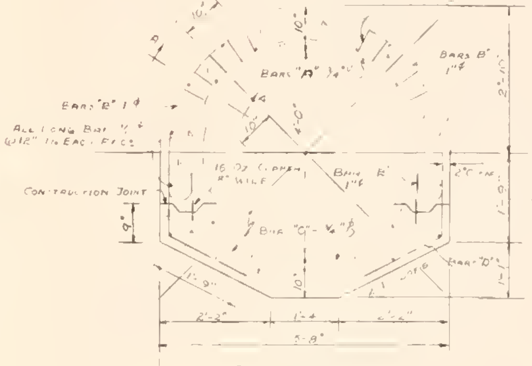


SECTION [illegible]

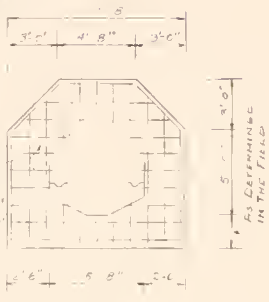
5 - ⅜"Ø Stirrups @ 5" At
Sta 42+66 To Sta 43+85 [illegible]
Sta 12 [illegible] To Sta 14+05 [illegible]



SECTION A-A



CONDUIT SECTION
¾"=1'



9' CONDUIT [illegible]
½"=1'

SCHEDULE OF CONDUIT REINFORCING

North Dam Stationing	East Dam Stationing	"A" [illegible]	"B" - Bars	"C" Bars	"D" - Bars
42+98 - 43+65	13+18 - [illegible]	[illegible]	1"Ø @ 10"	[illegible]	1" [illegible]
42+68 - 42+98 43+65 - 43+85	12+88 - [illegible] 13+[illegible] - 14+[illegible]	¾"Ø @ 6"	1"Ø @ 12"	¾"Ø @ 8"	1"Ø @ 12"
42+38 - 42+68 43+85 - 44+05	12+58 - 12+88 14+05 - 14+2[illegible]	¾"Ø @ 6"	1"Ø @ 20"	¾"Ø @ 1[illegible]"	1" @ 20"
42+08 - 42+38 44+05 - 44+25	[illegible] - 12+[illegible] 14+25 - [illegible]	¾" @ [illegible]	1"Ø @ 24"	¾"Ø @ 12"	1"Ø [illegible]"
41+22 - 42+08 44+25 - 44+44	12+[illegible] - [illegible] 14+45 - [illegible]	[illegible] @ 11"	1"Ø @ 24"	¾" @ 15"	1" @ 24"

[illegible] NOTES
[illegible] CONCRETE [illegible] MIN [illegible]
[illegible]
[illegible] BARS [illegible]
[illegible]
EXTEND [illegible]

1 "A" BARS ALTERNATE BARS [illegible] AS SHOWN EXCEPT FROM STA 42+38 TO STA 43+[illegible] NORTH DAM AND STA 12+58 TO STA 14+05 EAST DAM, WHERE STIRRUPS ARE [illegible] AND ALL BARS END [illegible]" BELOW 45° LINE

2. "B" BARS [illegible] [illegible] END 10" ABOVE 45° LINE

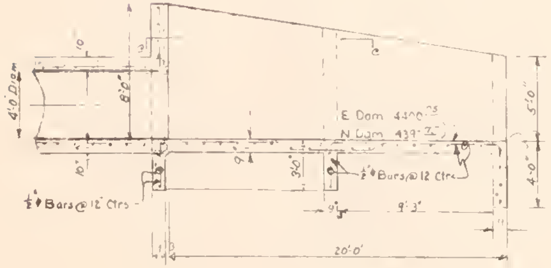
3 "C" BARS ALTERNATE [illegible] AS SHOWN.

4 "D" BARS [illegible] AND END AT 45° LINE EXCEPT FROM STA [illegible] TO STA 43+85 AND STA 12+88 TO STA 14+05 WHERE [illegible] ARE REQU AND ALL BARS END 10" ABOVE 45° LINE

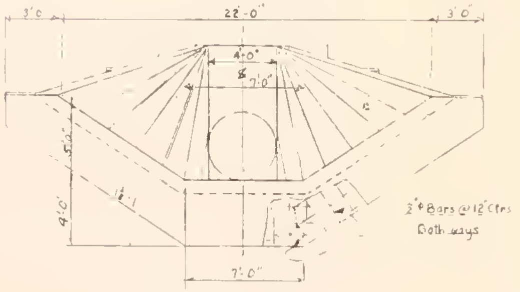
5 ALL LONGITUDINAL BARS ½"Ø @ 12" IN EACH FACE.

6 STIRRUPS ⅜"Ø @ 5" FROM STA 42+66 TO 43+85 NORTH DAM AND STA 12+88 TO STA 14+05 EAST DAM

7 16 OZ. COPPER SEAL 8" WIDE [illegible] IN ALL CONSTRUCTION JOINT



SECTION B-B



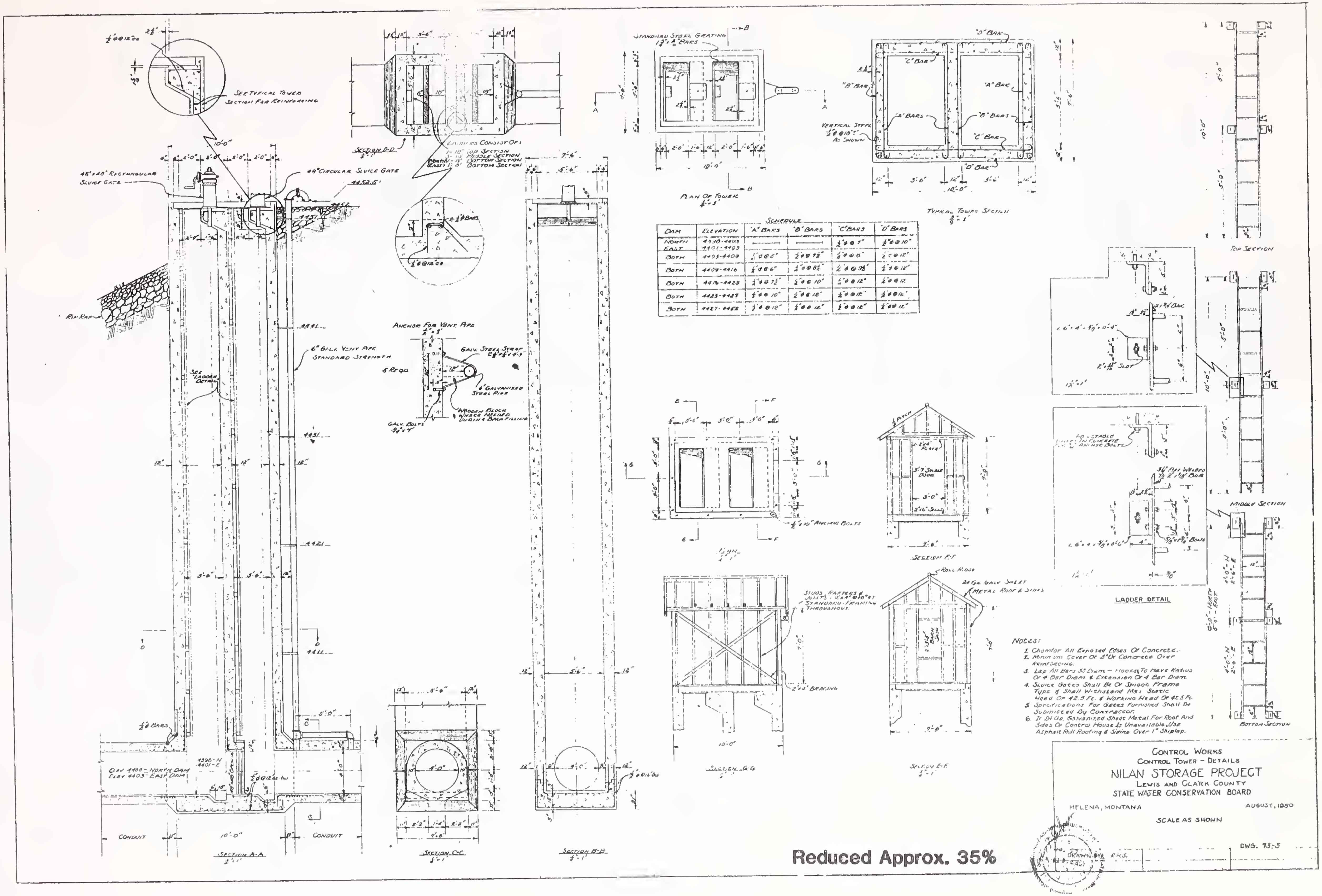
END ELEVATION

OUTLET STRUCTURE
Scale ¼" = 1'

CONTROL WORKS - NORTH DAM
CONDUIT & OUTLET STRUCTURES
LEWIS & CLARK COUNTY
STATE WATER CONSERVATION BOARD

Helena, Montana Dec. 1942
Scale as Shown
Dwg. No. 73 - 3

PLATE 7



Schedule

Dam	Elevation	"A" Bars	"B" Bars	"C" Bars	"D" Bars
North East	4398-4403 4401-4403	—	—	½" Ø @ 7"	½" Ø @ 10"
Both	4403-4409	½" Ø @ 5"	½" Ø @ 7½"	½" Ø @ 8"	½" Ø @ 12"
Both	4409-4416	½" Ø @ 6"	½" Ø @ 8½"	½" Ø @ 9½"	½" Ø @ 12"
Both	4416-4425	½" Ø @ 7½"	½" Ø @ 10"	½" Ø @ 12"	½" Ø @ 12
Both	4425-4427	½" Ø @ 10"	½" Ø @ 12"	½" Ø @ 12"	½" Ø @ 12"
Both	4427-4452	½" Ø @ 12"	½" Ø @ 12"	½" Ø @ 12"	½" Ø @ 12"

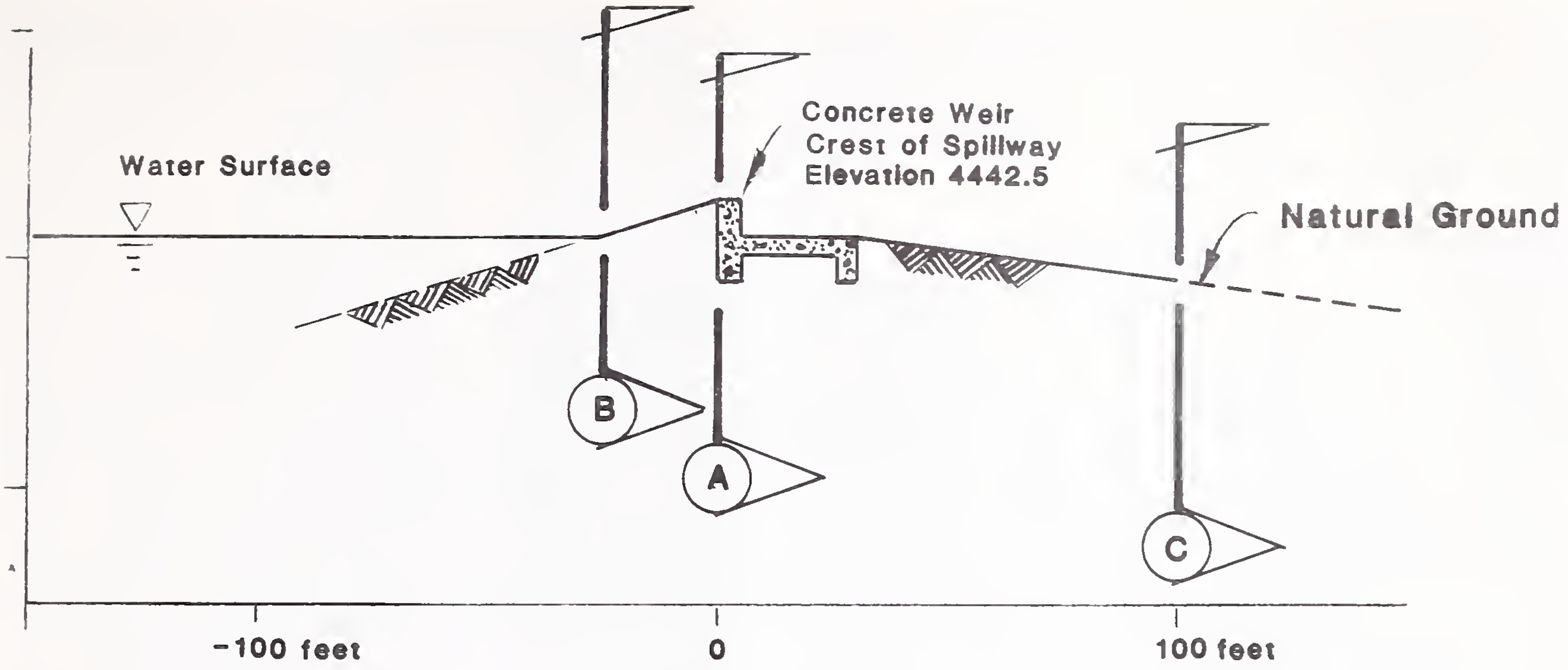
Notes:

1. Chamfer All Exposed Edges Of Concrete.
2. Minimum Cover Of 3" Of Concrete Over Reinforcing.
3. Lap All Bars 30 Diam - Hooks To Have Radius Of 4 Bar Diam. & Extension Of 4 Bar Diam.
4. Sluice Gates Shall Be Of Spigot Frame Type & Shall Withstand Max. Static Head Of 42.5 Ft. & Working Head Of 42.5 Ft.
5. Specifications For Gates Furnished Shall Be Submitted By Contractor.
6. If 24 Ga. Galvanized Sheet Metal For Roof And Sides Of Control House Is Unavailable, Use Asphalt Roll Roofing & Siding Over 1" Shiplap.

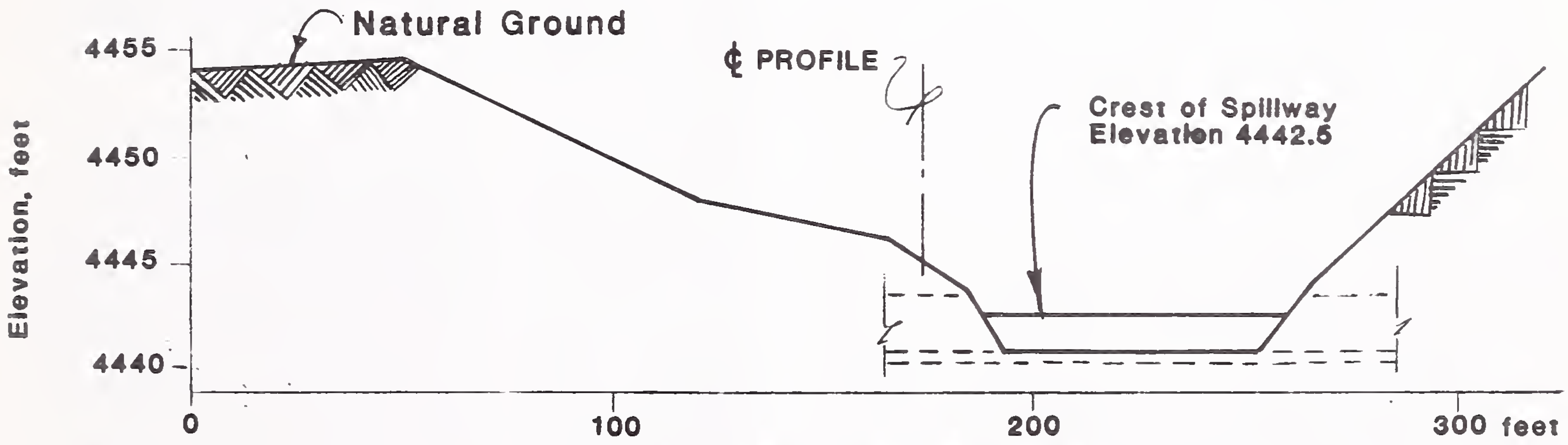
CONTROL WORKS
CONTROL TOWER - DETAILS
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA
AUGUST, 1950
SCALE AS SHOWN
DWG. 73-5

CONTROL WORKS

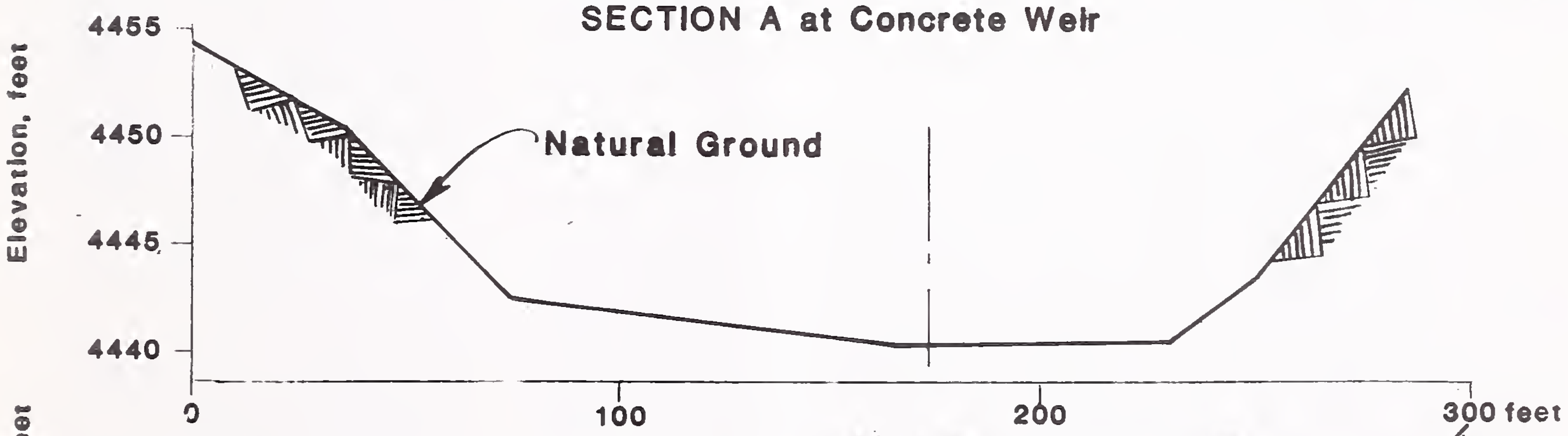
PLATE 8



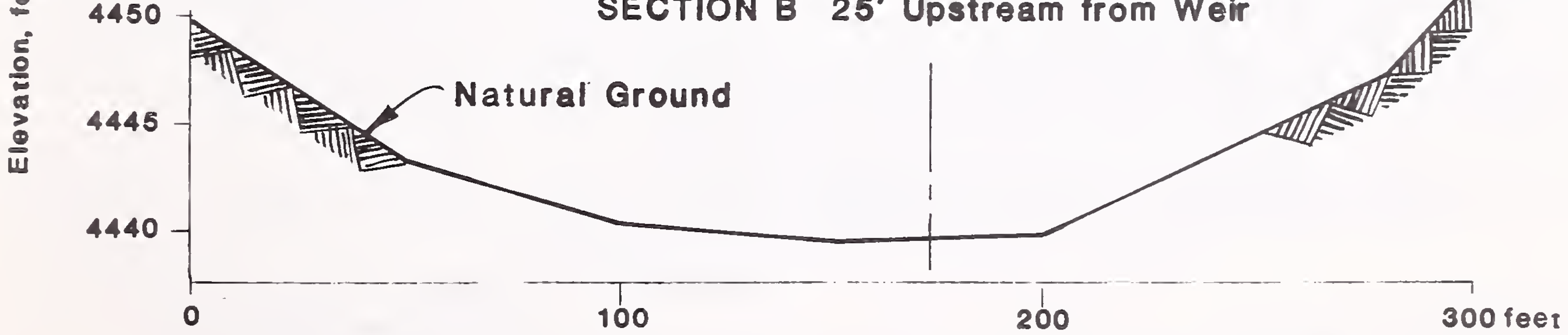
SPILLWAY PROFILE



SECTION A at Concrete Weir



SECTION B 25′ Upstream from Weir

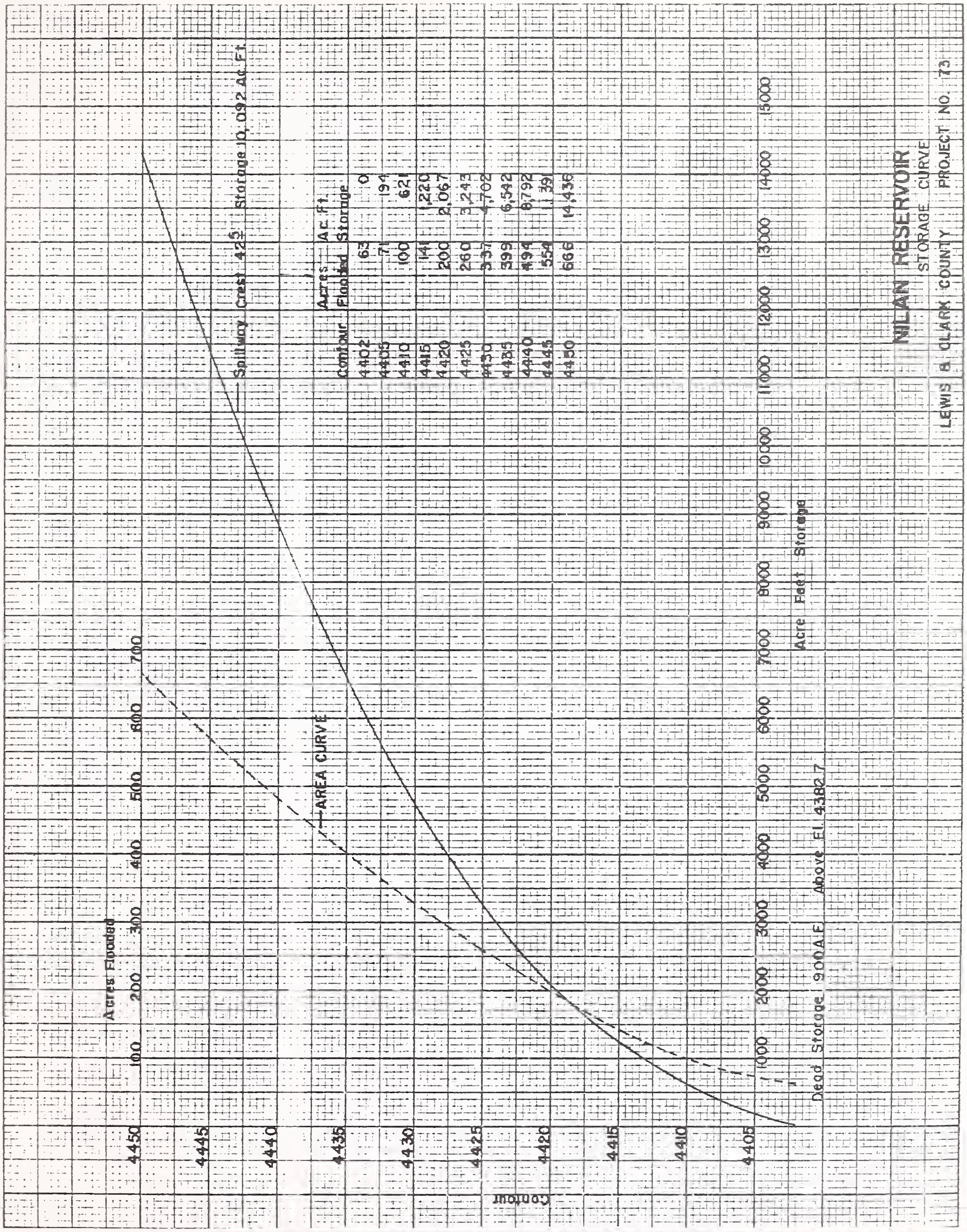


SECTION C 100′ Downstream from Weir

SPILLWAY CROSS-SECTIONS

PROJECT SPILLWAY

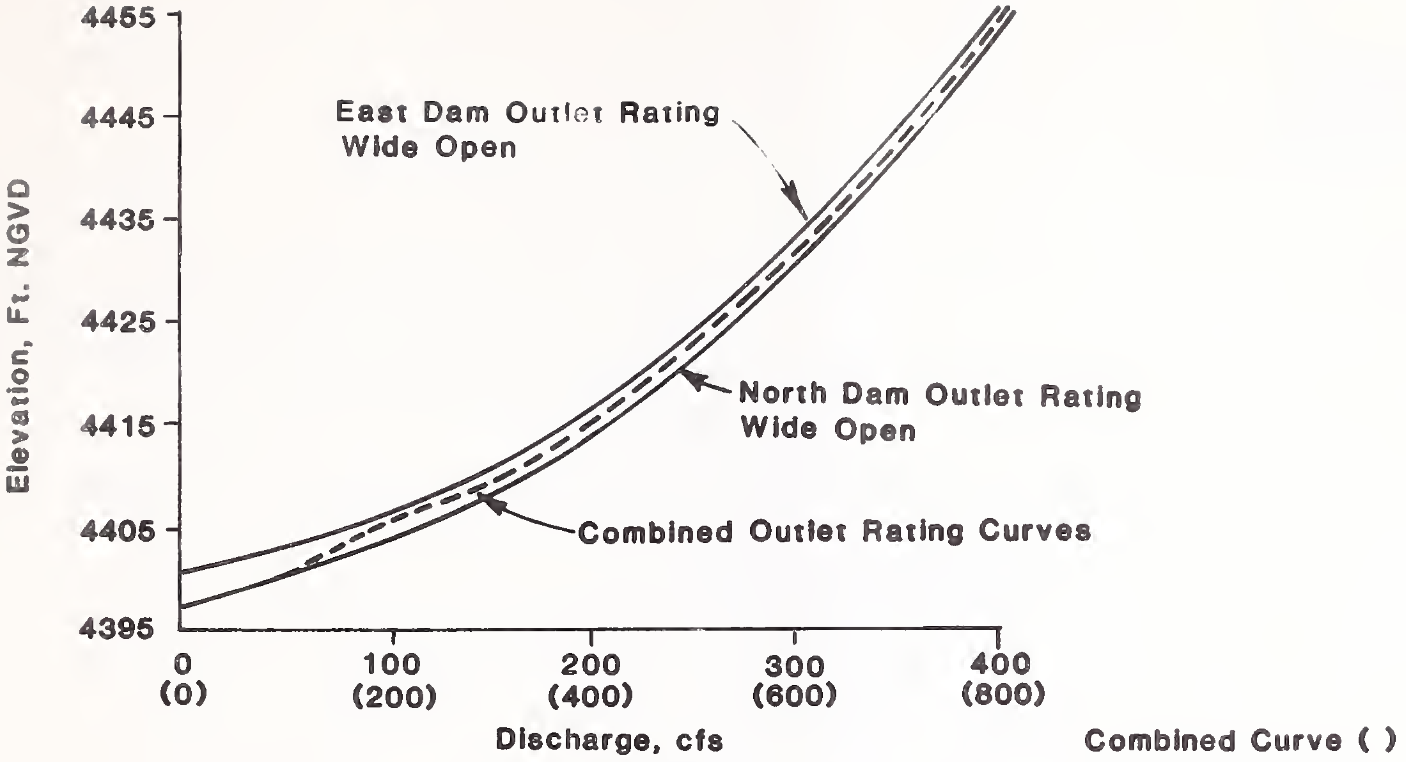
PLATE 9



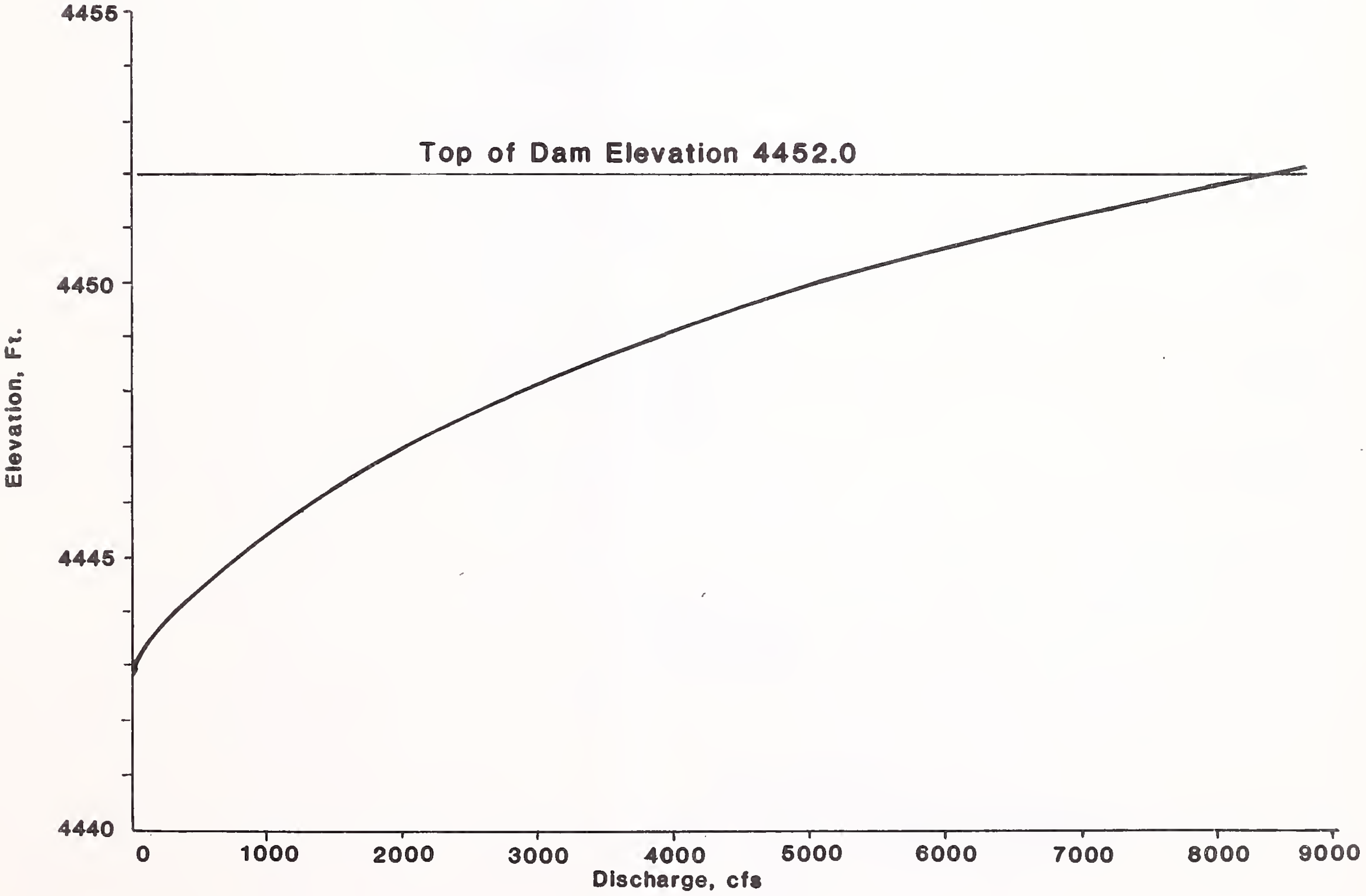
Contour	Acres Flooded	Ac Ft. Storage
4402	63	0
4405	71	194
4410	100	621
4415	141	1,220
4420	200	2,067
4425	260	3,243
4430	337	4,702
4435	399	6,542
4440	494	8,792
4445	554	11,391
4450	666	14,436

Source: STATE WATER CONSERVATION PROJECTS,
Water Resources Division,
Montana Department of Natural Resources & Conservation

NILAN RESERVOIR
AREA CURVE AND
STORAGE CURVE
PLATE 10



NILAN DAMS
PRINCIPAL OUTLET WORKS RATING



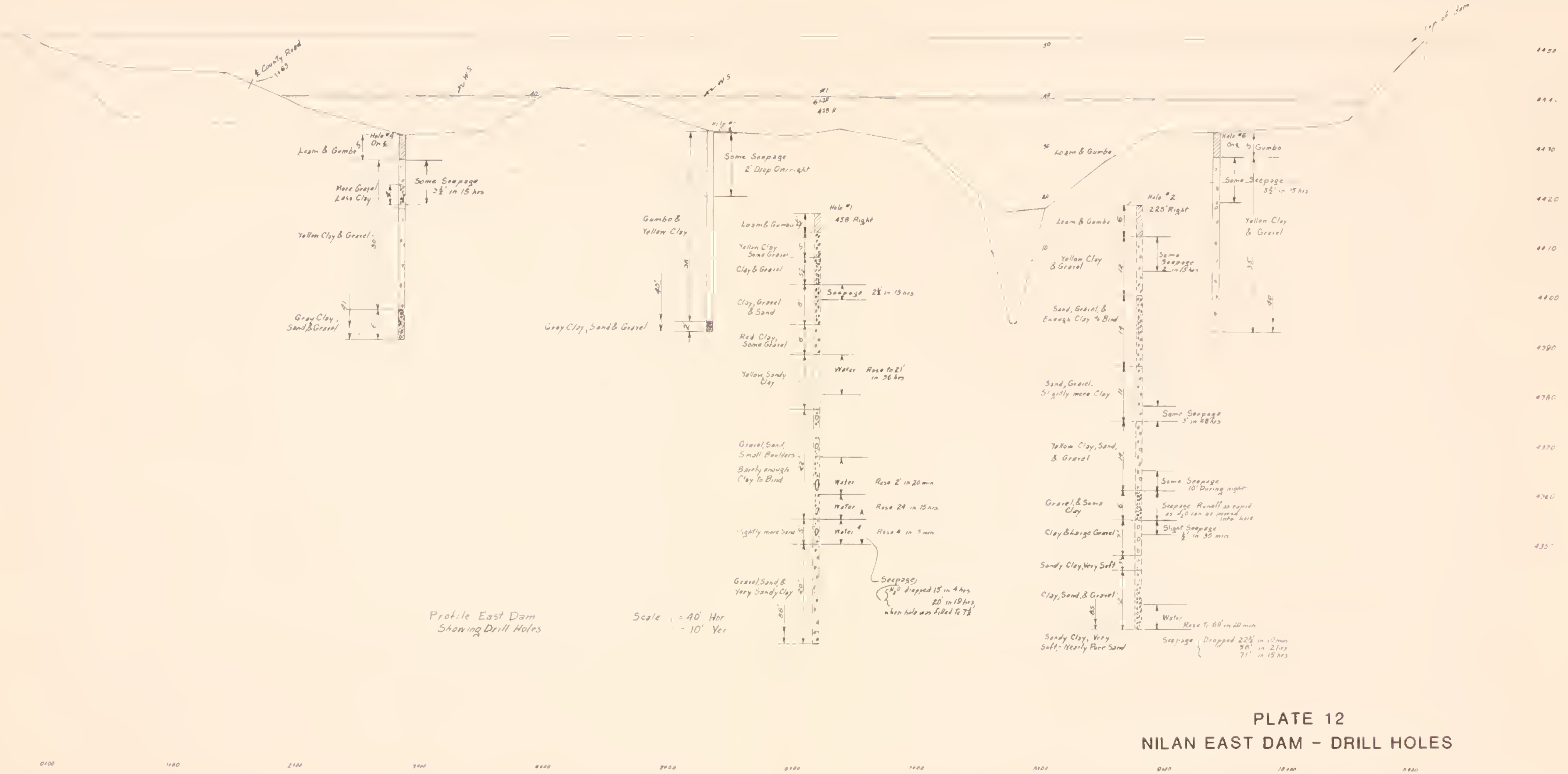
NILAN DAMS
EMERGENCY SPILLWAY RATING CURVE

SPILLWAY DISCHARGE RATING CURVE

PLATE 11

"NOTICE"

THIS SET OF PLANS HAS BEEN REDUCED TO ONE-HALF SIZE. MODIFY SCALES ACCORDINGLY.



℄ County Road 11+63
N.W.S.
N.W.S.
#1 6+21 458 R
Top of dam
Hole #4 On ℄
Loam & Gumbo 5
Some Seepage 3½' in 15 hrs
More Gravel Less Clay
Yellow Clay & Gravel 30
Gray Clay, Sand & Gravel
Hole #5
Some Seepage 2' Drop Overnight
Gumbo & Yellow Clay
38
40'
Grey Clay, Sand & Gravel 2
Hole #1 458 Right
Loam & Gumbo 4
Yellow Clay Some Gravel 5
Clay & Gravel
Seepage 2½' in 13 hrs
Clay, Gravel & Sand 8
Red Clay, Some Gravel 6
Yellow Sandy Clay
Water Rose to 21' in 36 hrs
Gravel, Sand, Small Boulders
Barely enough Clay to Bind
Water Rose 2' in 20 min
Water Rose 24 in 15 hrs
Slightly more Sand 5
Water Rose 4 in 5 min
Seepage, H₂O dropped 15' in 4 hrs 20' in 19 hrs, when hole was filled to 7½'
Gravel, Sand & Very Sandy Clay 20'
86'
Loam & Gumbo
Hole #2 225' Right
Loam & Gumbo 6
Yellow Clay & Gravel 12
Some Seepage 2 in 15 hrs
Sand, Gravel, & Enough Clay to Bind
Sand, Gravel. Slightly more Clay 11
Some Seepage 3' in 48 hrs
Yellow Clay, Sand, & Gravel
Some Seepage 10' During night
Gravel, & Some Clay 6
Seepage Runoff as rapid as H₂O can be poured into hole
Clay & Large Gravel
Slight Seepage ½' in 35 min
Sandy Clay, Very Soft
Clay, Sand, & Gravel
85
Water Rose to 69' in 20 min
Sandy Clay, Very Soft - Nearly Pure Sand
Seepage Dropped 22½' in 10 min 36' in 2 hrs 71' in 15 hrs
Hole #6 On ℄
5 Gumbo
Some Seepage 3½' in 15 hrs
Yellow Clay & Gravel
35
40
Profile East Dam Showing Drill Holes
Scale 1" = 40' Hor 1" = 10' Ver
4450
4440
4430
4420
4410
4400
4390
4380
4370
4360
4350
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00

PLATE 12
NILAN EAST DAM - DRILL HOLES

Source: STATE WATER CONSERVATION PROJECTS
Water Resources Division, Montana Department
of Natural Resources and Conservation

"NOTICE"
THIS SET OF PLANS HAS BEEN
REDUCED TO ONE-HALF SIZE.
MODIFY SCALES ACCORDINGLY

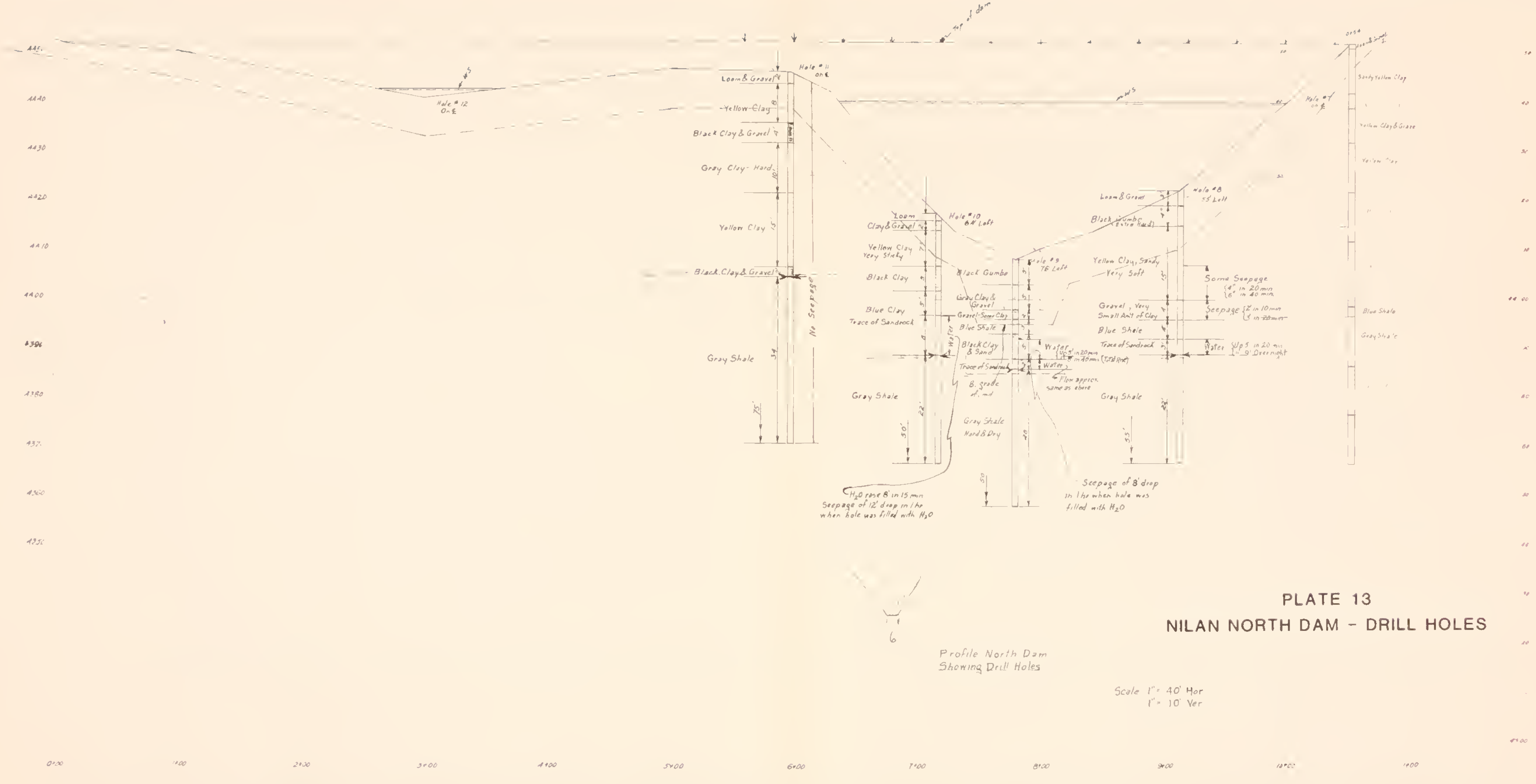
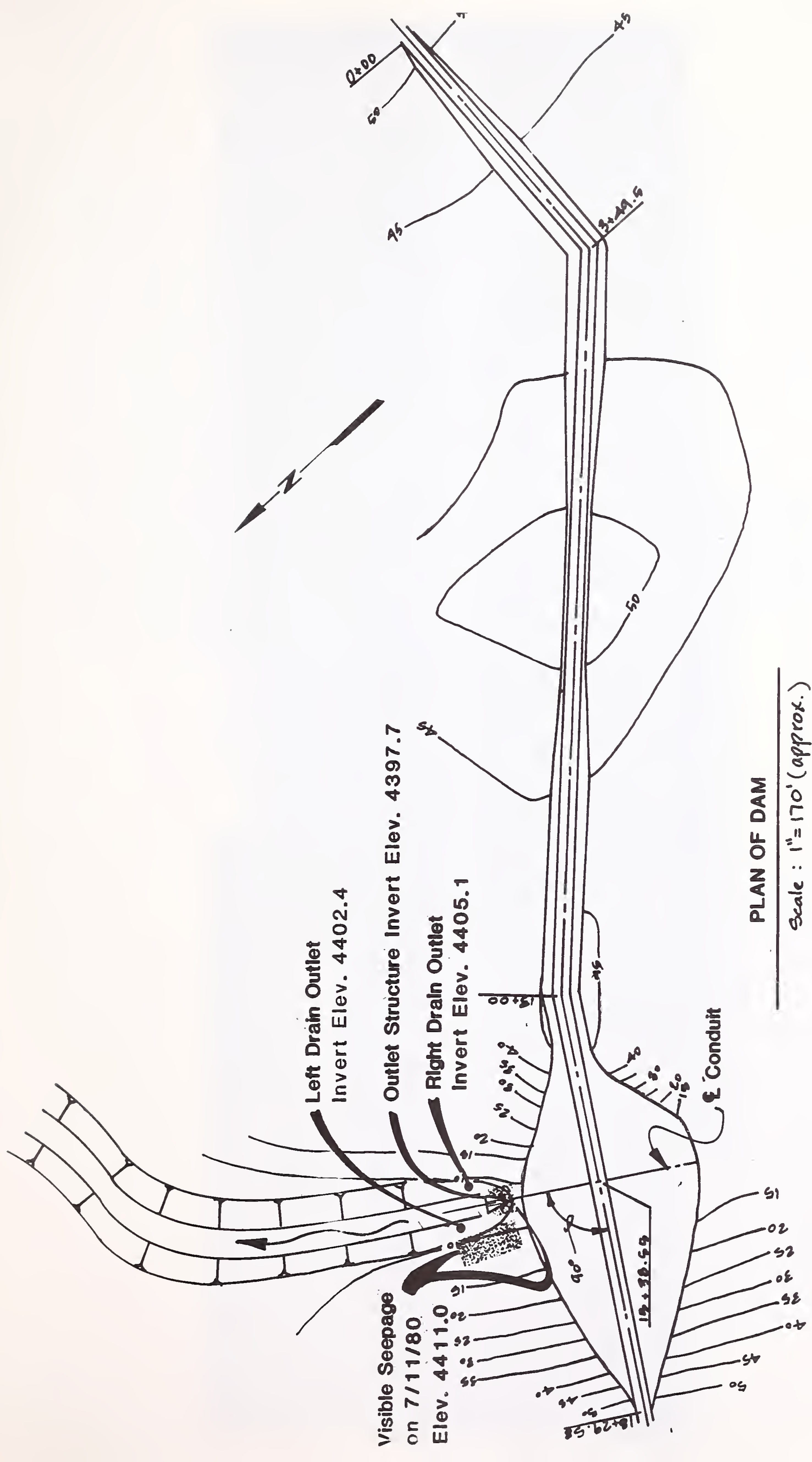


PLATE 13

NILAN NORTH DAM - DRILL HOLES

Source: STATE WATER CONSERVATION PROJECTS
Water Resources Division, Montana Department
of Natural Resources and Conservation



NORTH DAM DRAINS

PLATE 14

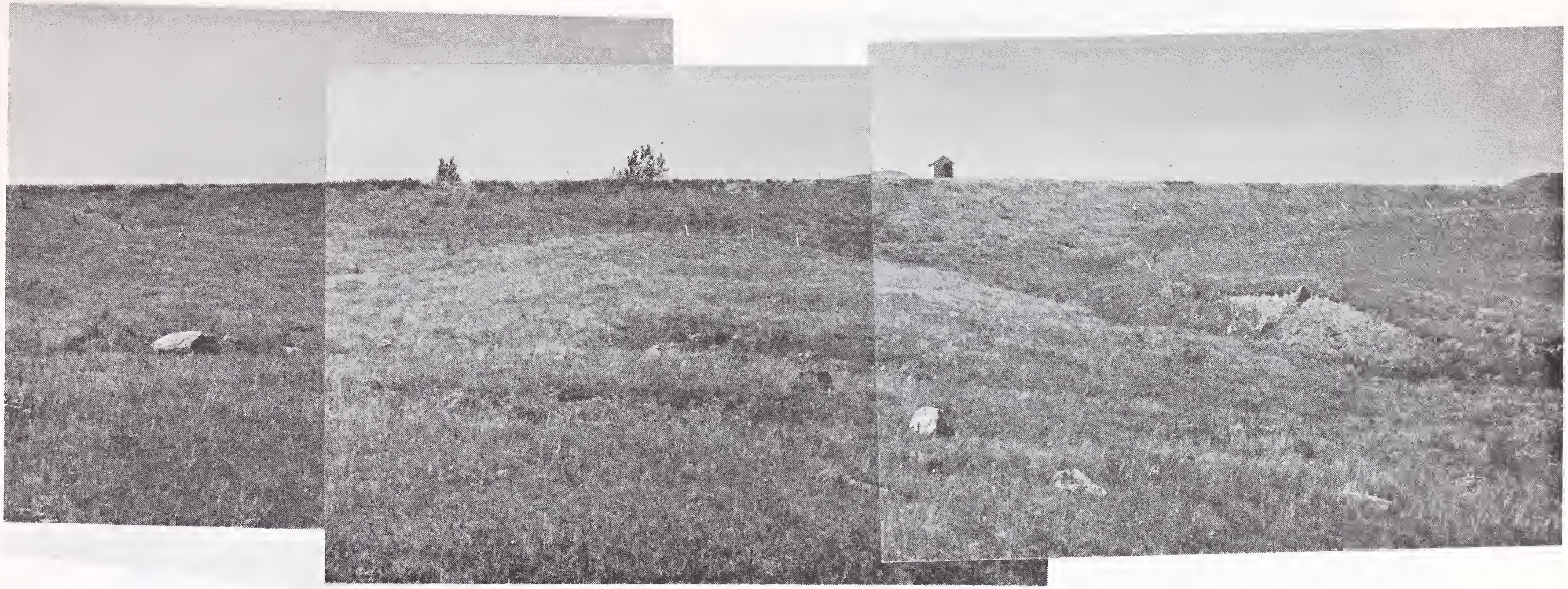


Photo 1. East Dam Downstream Slope

Photo 2. East Dam Downstream Area and Outlet Canal

Photo 3. East Dam Upstream Slope

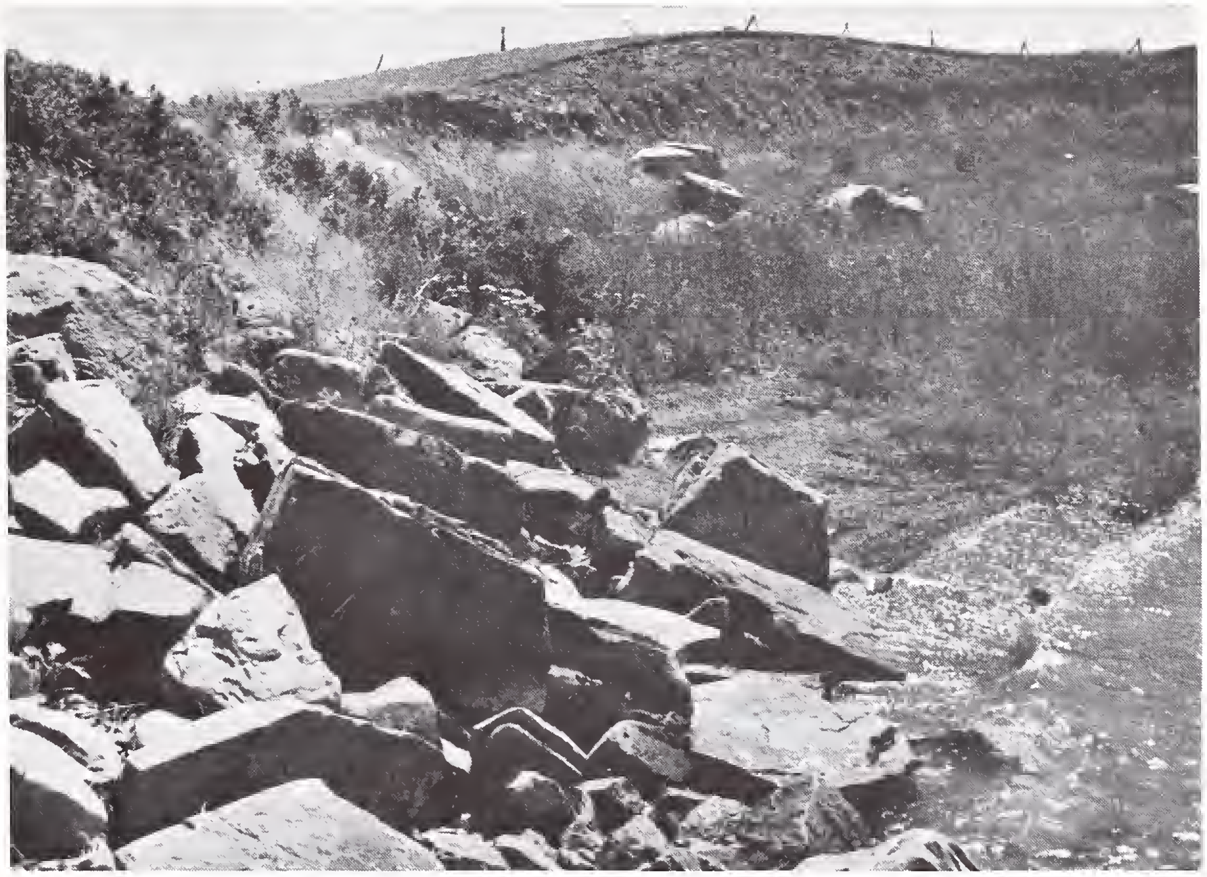


Photo 4. East Dam Right Abutment

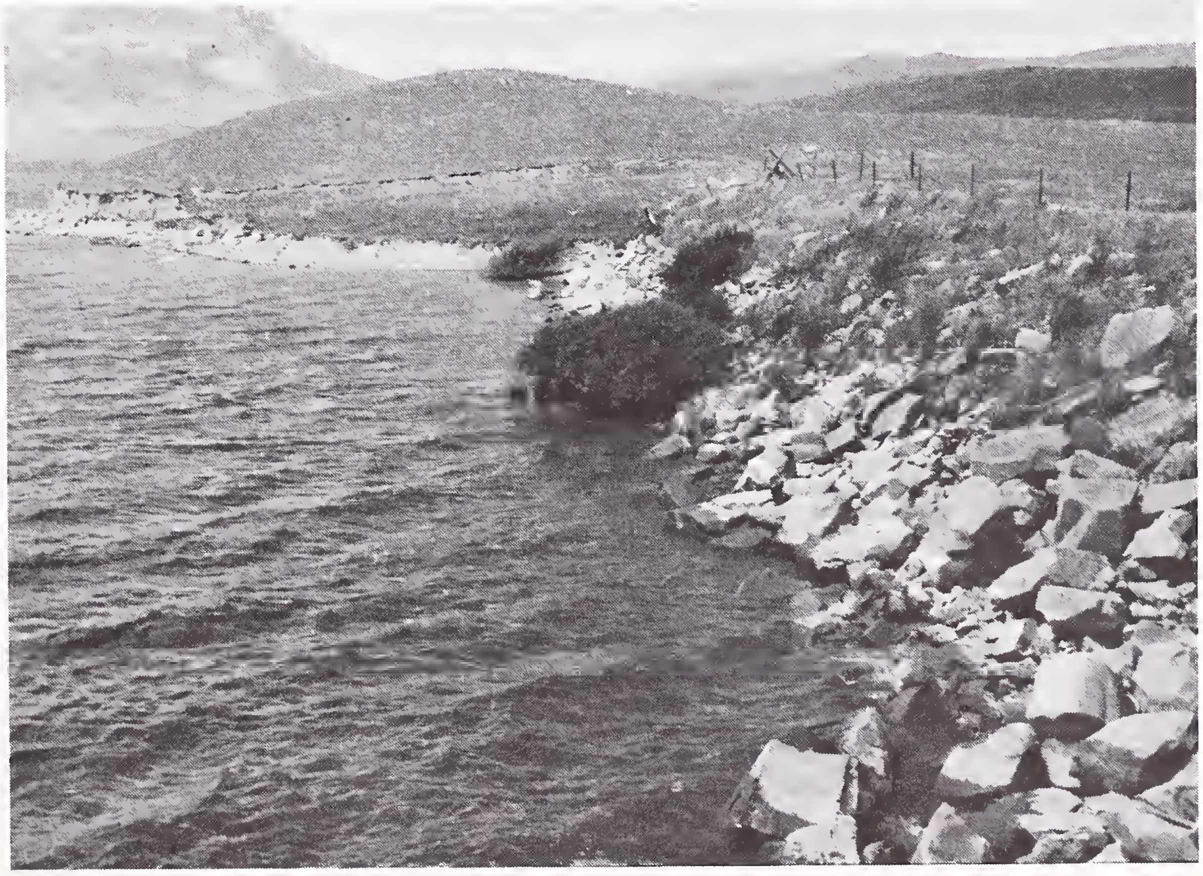


Photo 5. East Dam Left Abutment

Photo 6. East Dam Crest

Photo 7. East Dam Angle Point in Embankment

Photo 8. East Dam Outlet and Control Tower

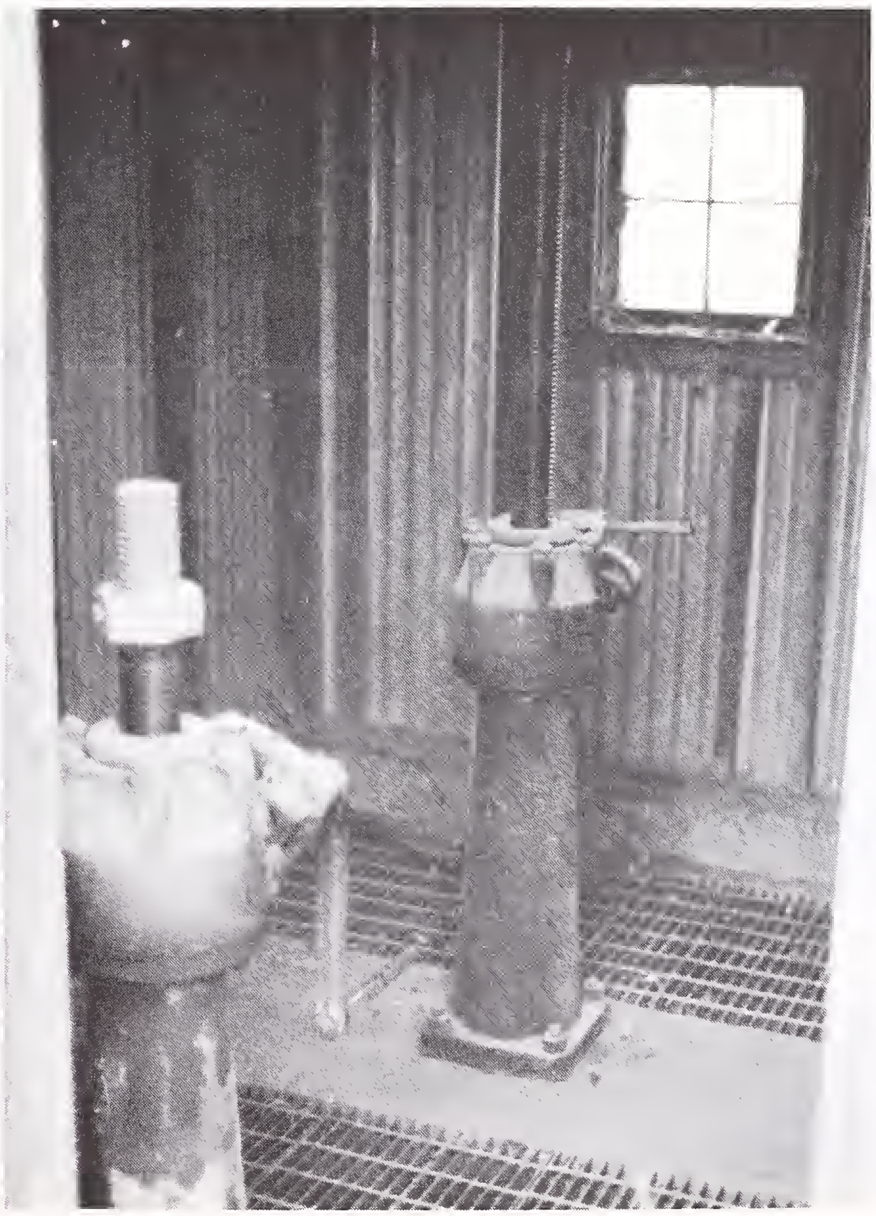


Photo 9. East Dam Gate Controls

Photo 10. East Dam Outlet Conduit Section

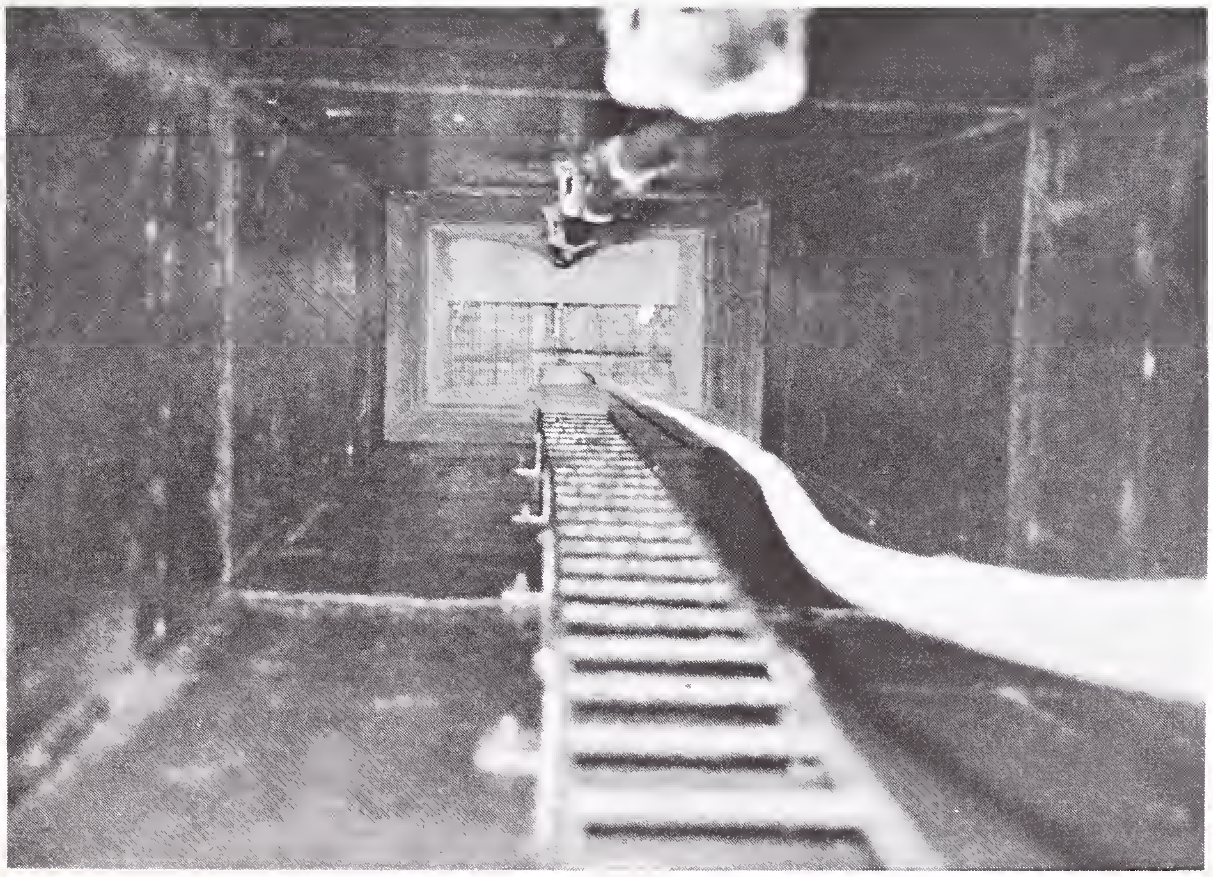


Photo 11. East Dam Control Works Wet Well

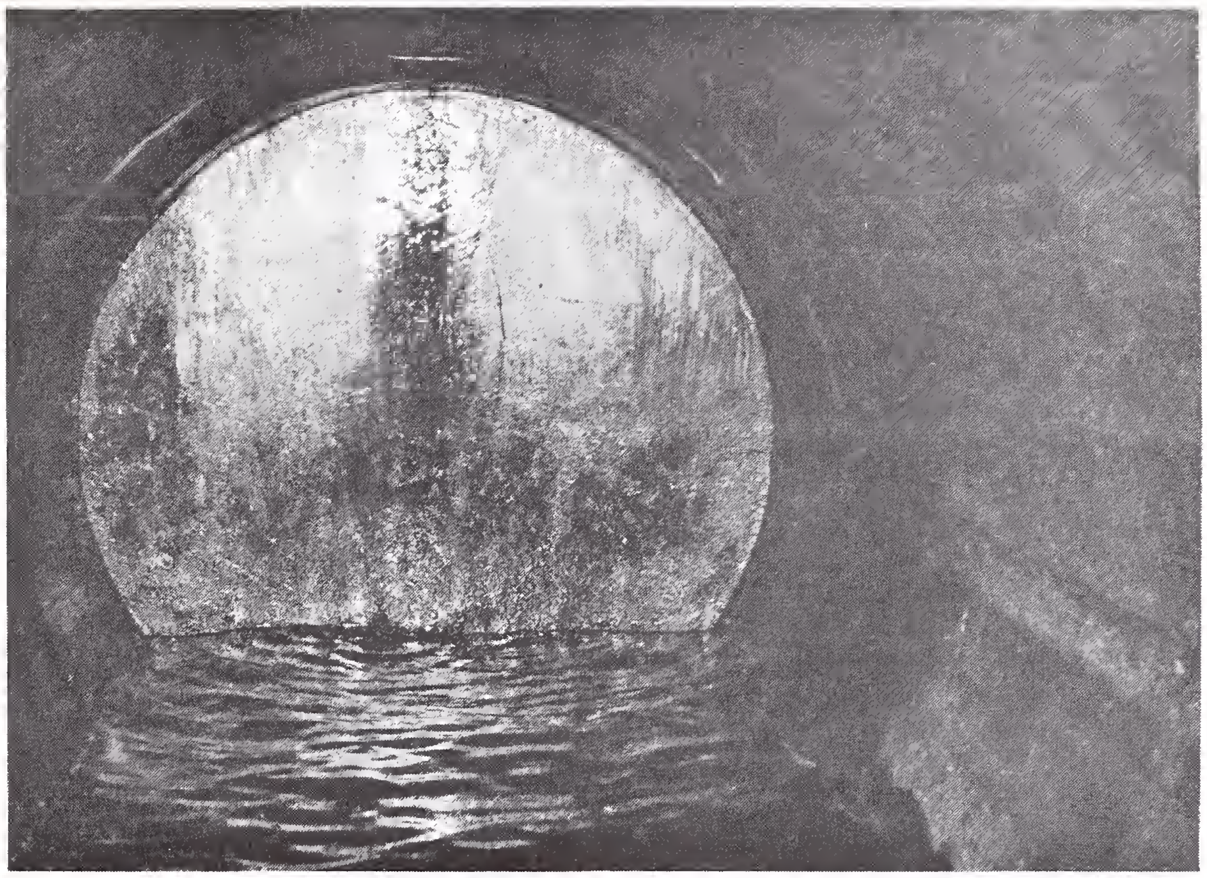


Photo 12. East Dam Operating Gate from Inside Conduit

Photo 13. East Dam Air Vent

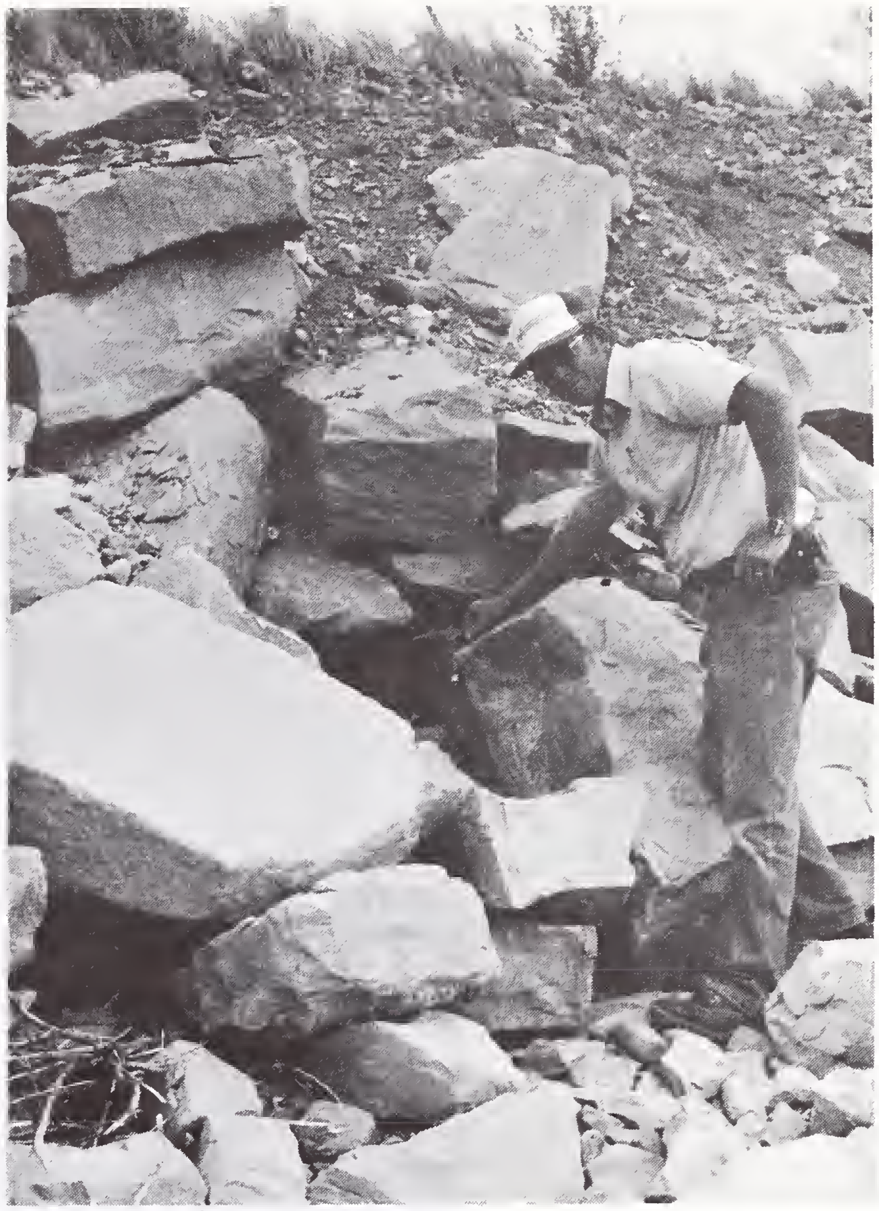


Photo 14. East Dam Eroded Riprap

Photo 15. East Dam Depression Between Dam and County Road

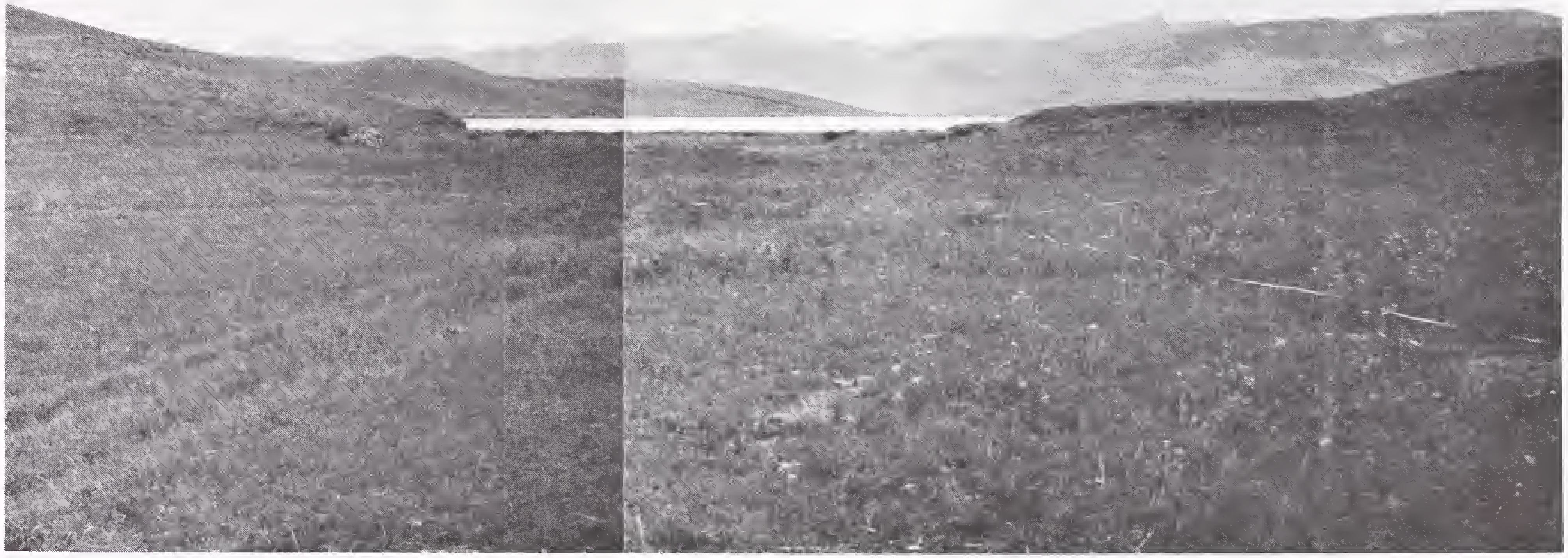


Photo 16. Project Spillway Concrete Retaining Wall

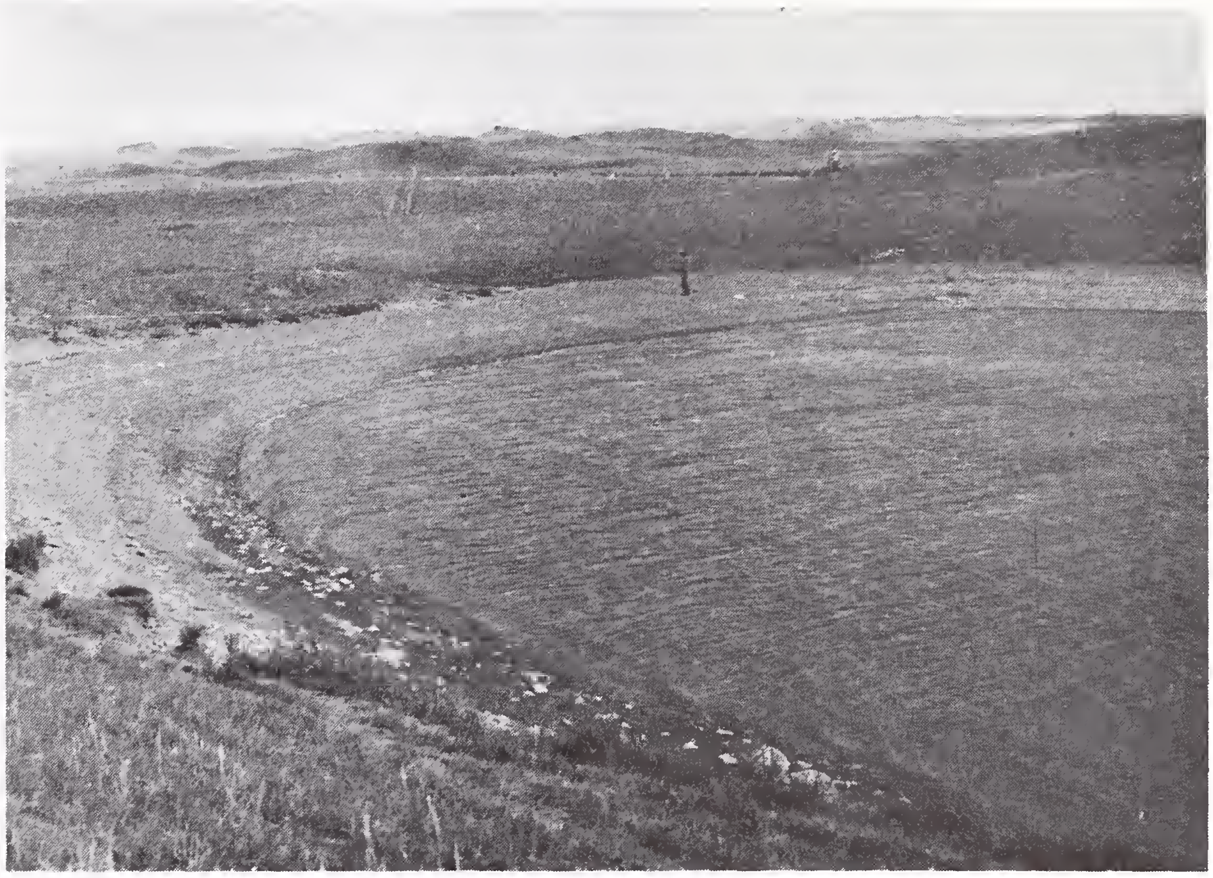


Photo 17. Spillway Approach to Concrete Wall

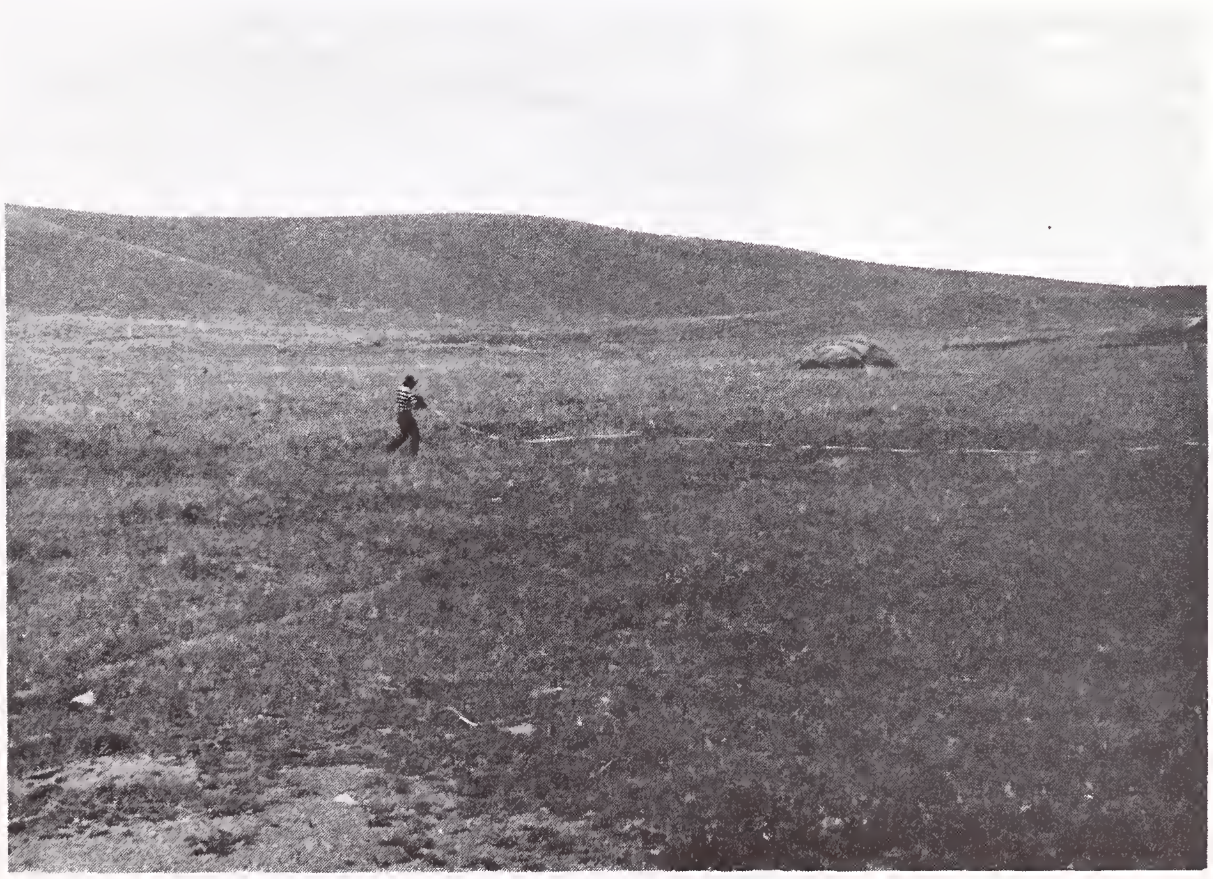


Photo 18. Spillway Discharge Channel Looking Downstream

Photo 19. North Dam Downstream Slope

Photo 20. North Dam Outlet Canal and Downstream Area

Photo 21. North Dam Downstream Slope

Photo 22. North Dam Crest

Photo 23. North Dam Upstream Slope

Photo 24. North Dam Control Tower and Outlet

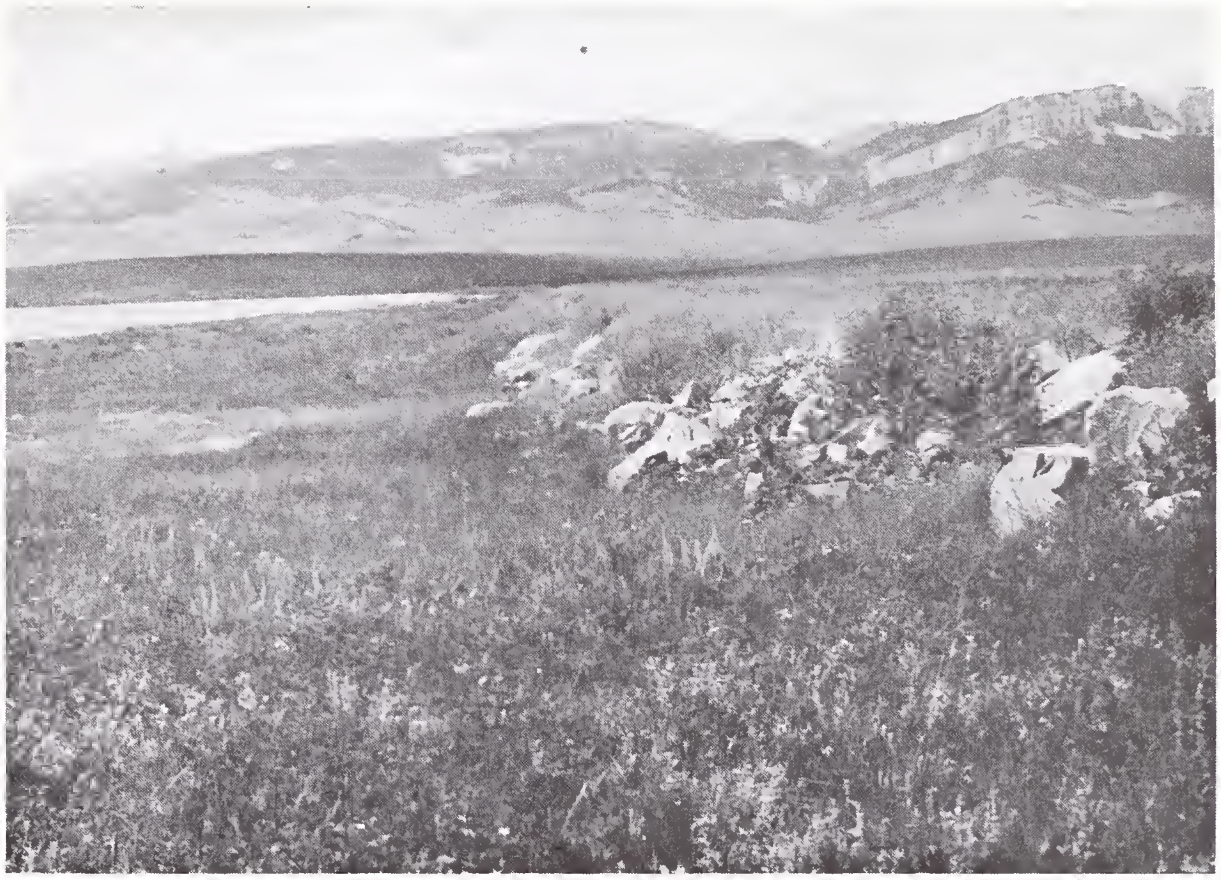


Photo 25. North Dam Dike, Upstream Slope

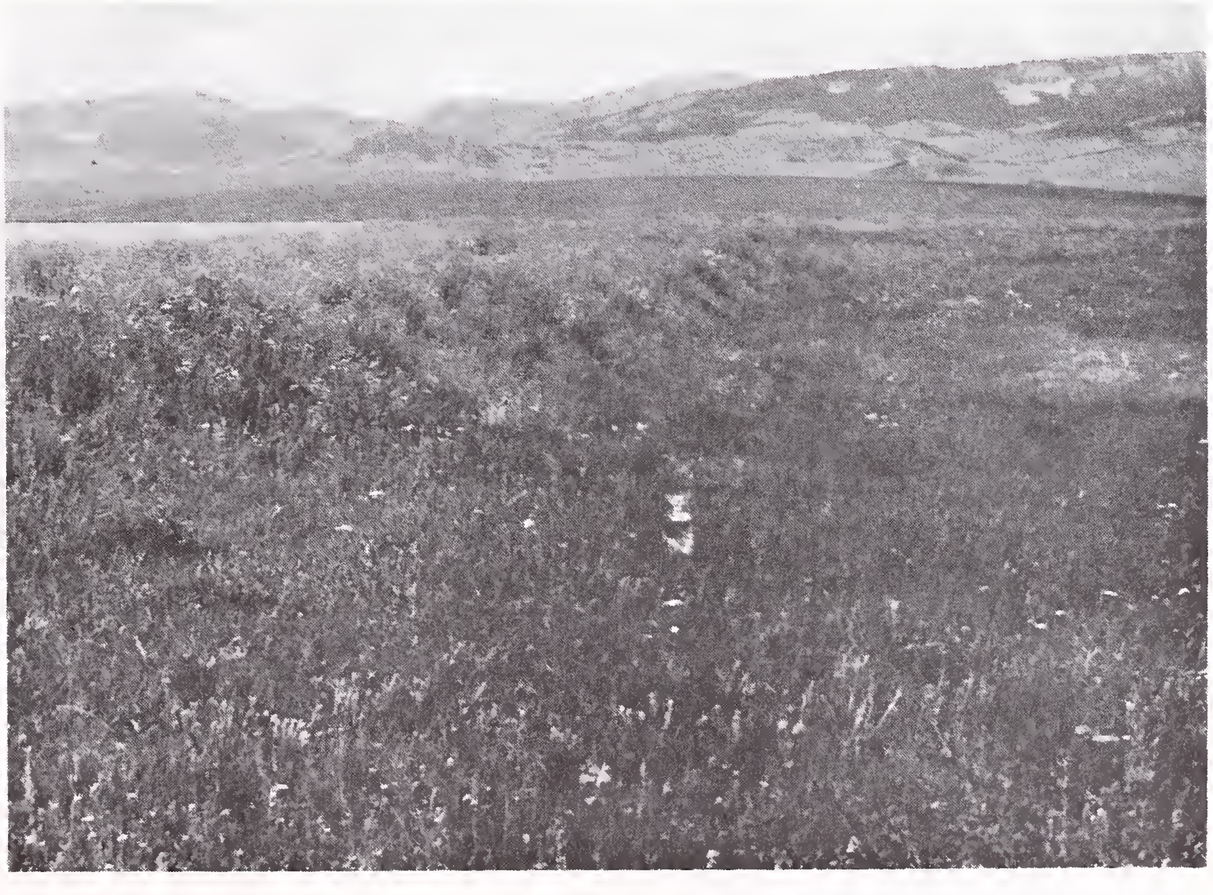


Photo 26. North Dam Dike, Downstream Slope

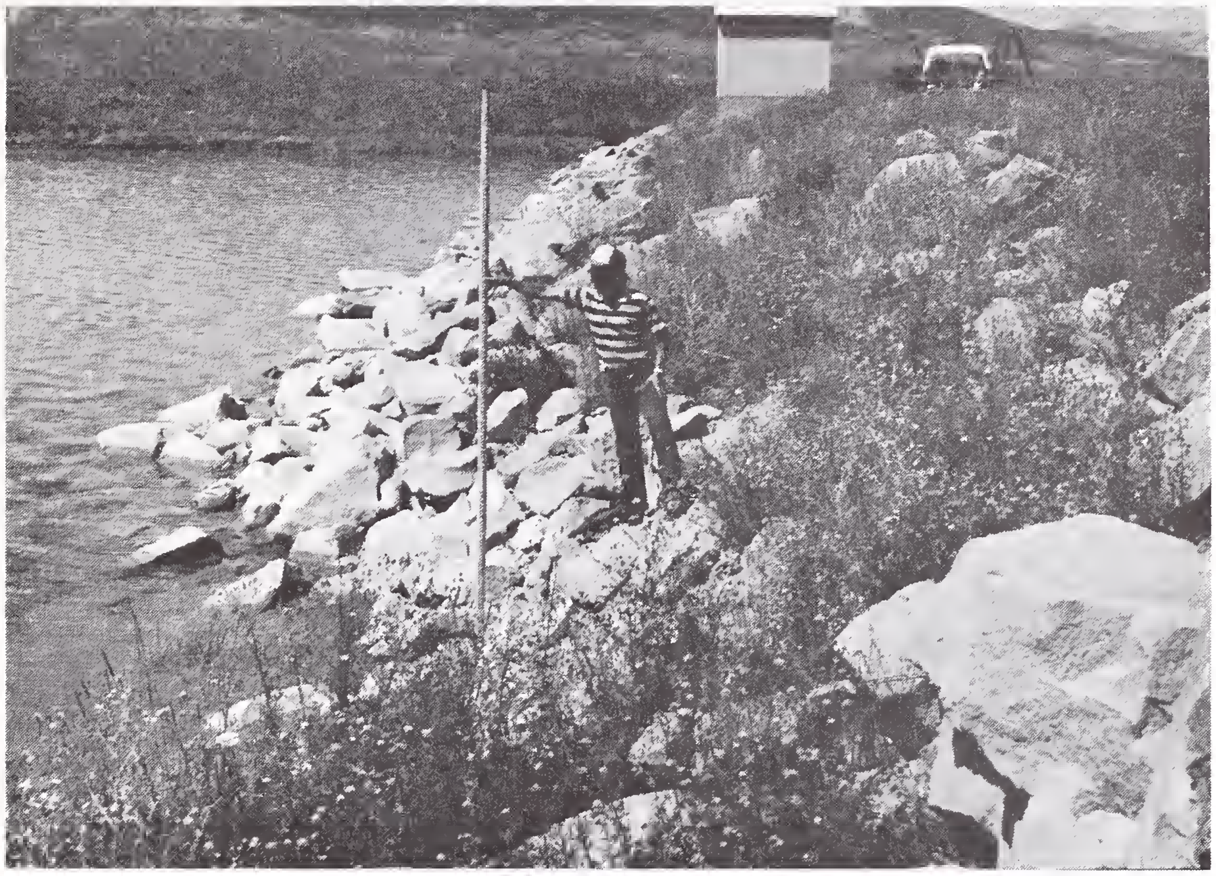


Photo 27. North Dam Eroded Riprap at Right Abutment

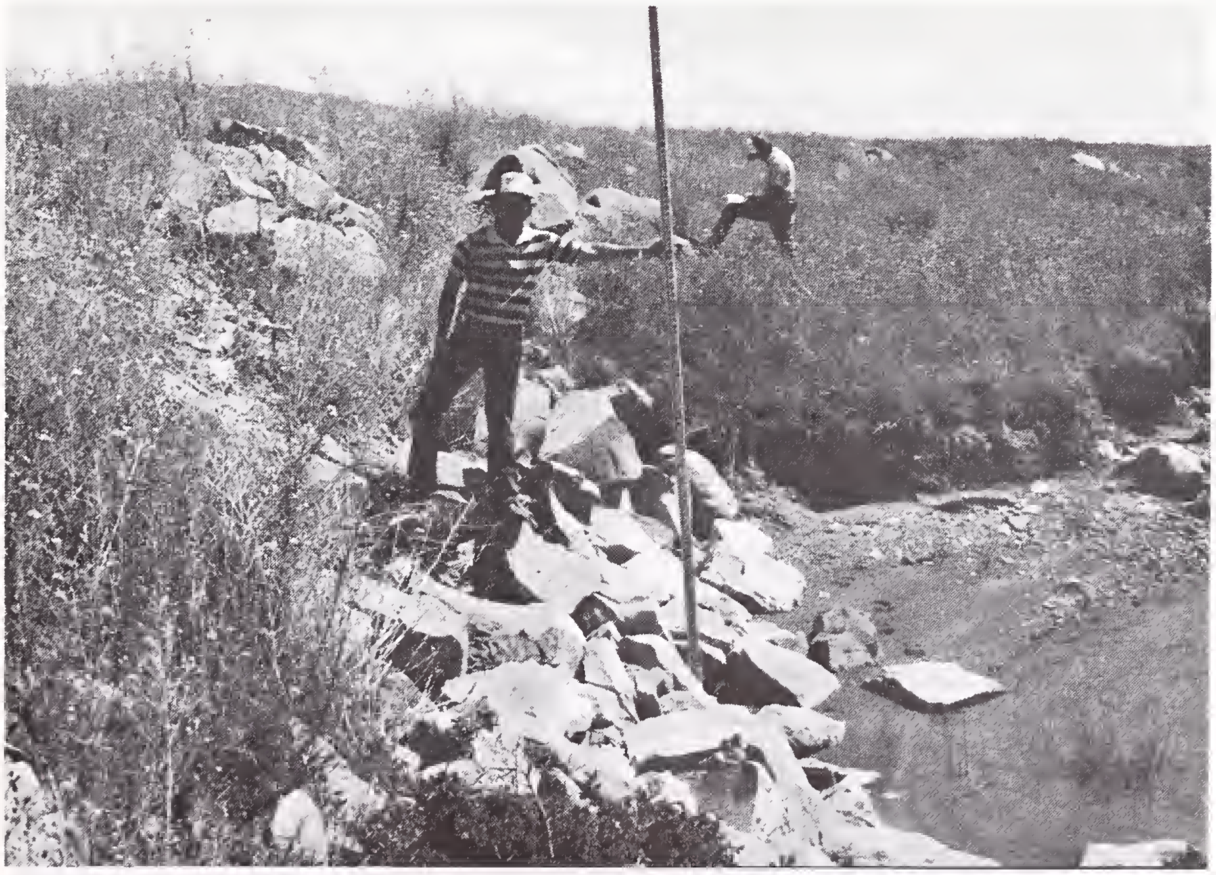


Photo 28. North Dam Right Abutment

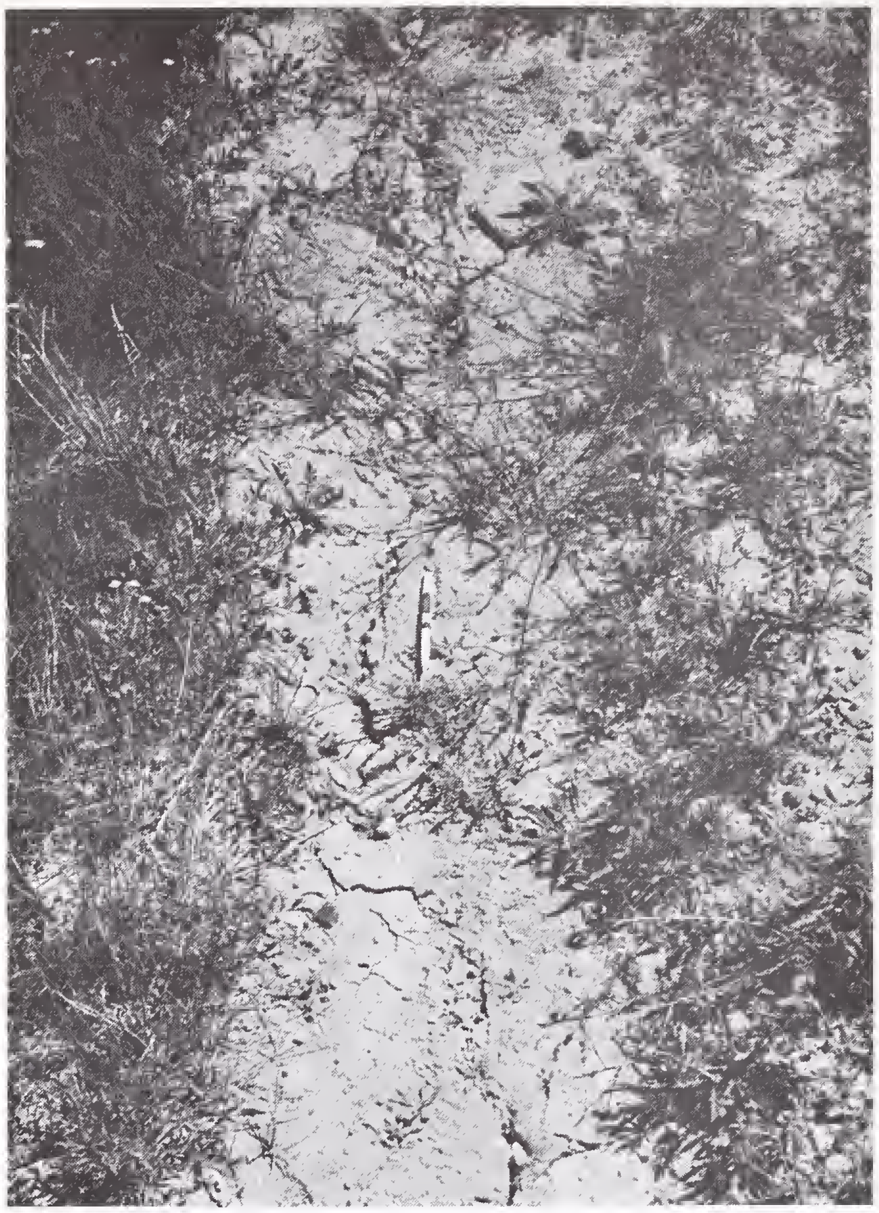


Photo 29. North Dam Shrinkage Crack in Soil on Dam Crest

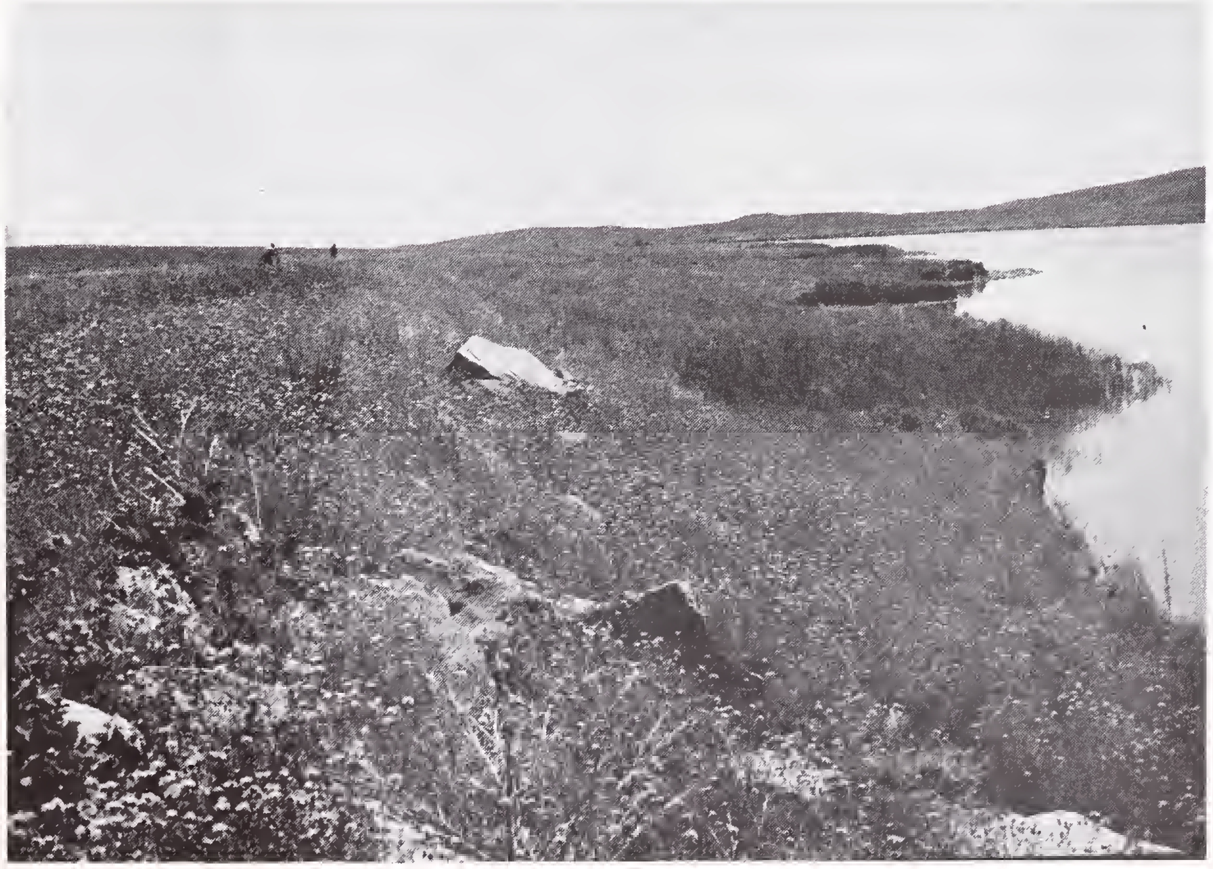


Photo 30. North Dam Eroded Shore Line Along Dike

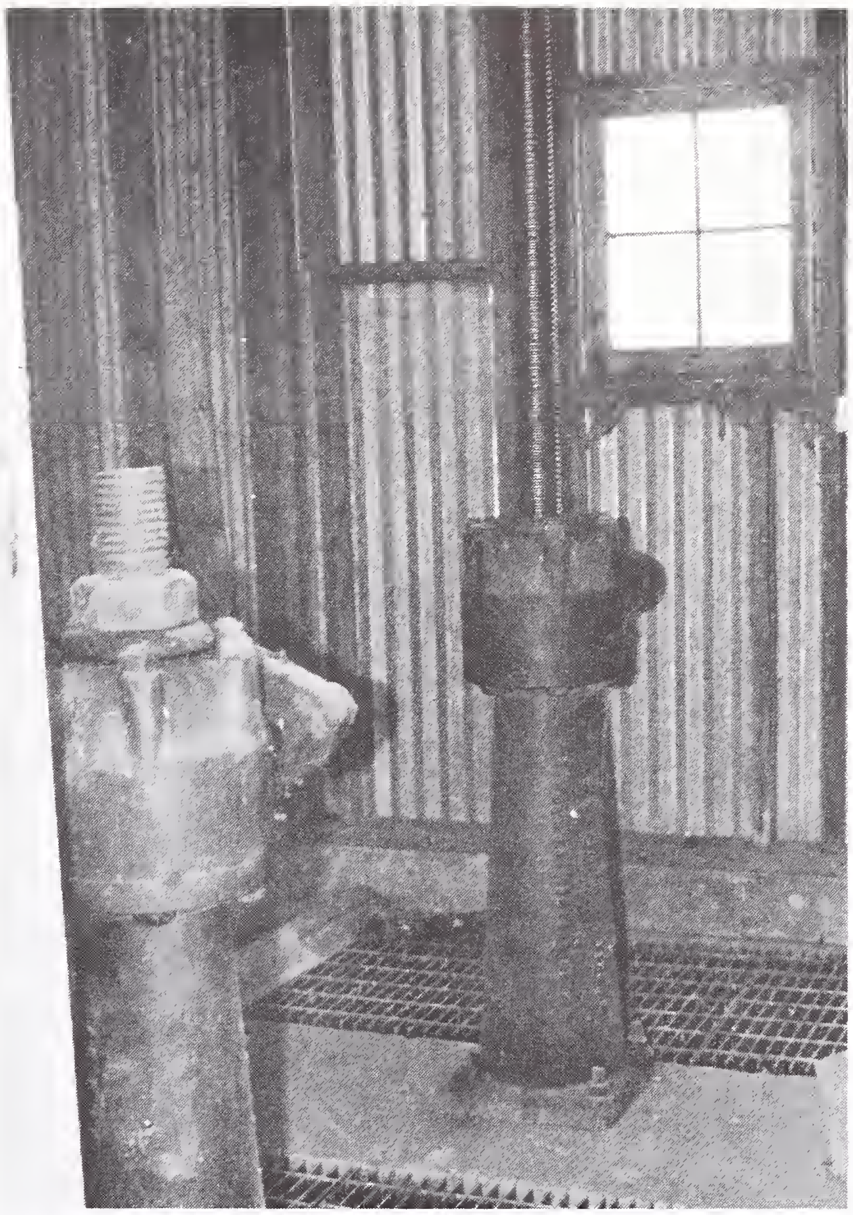


Photo 31. North Dam Gate Controls

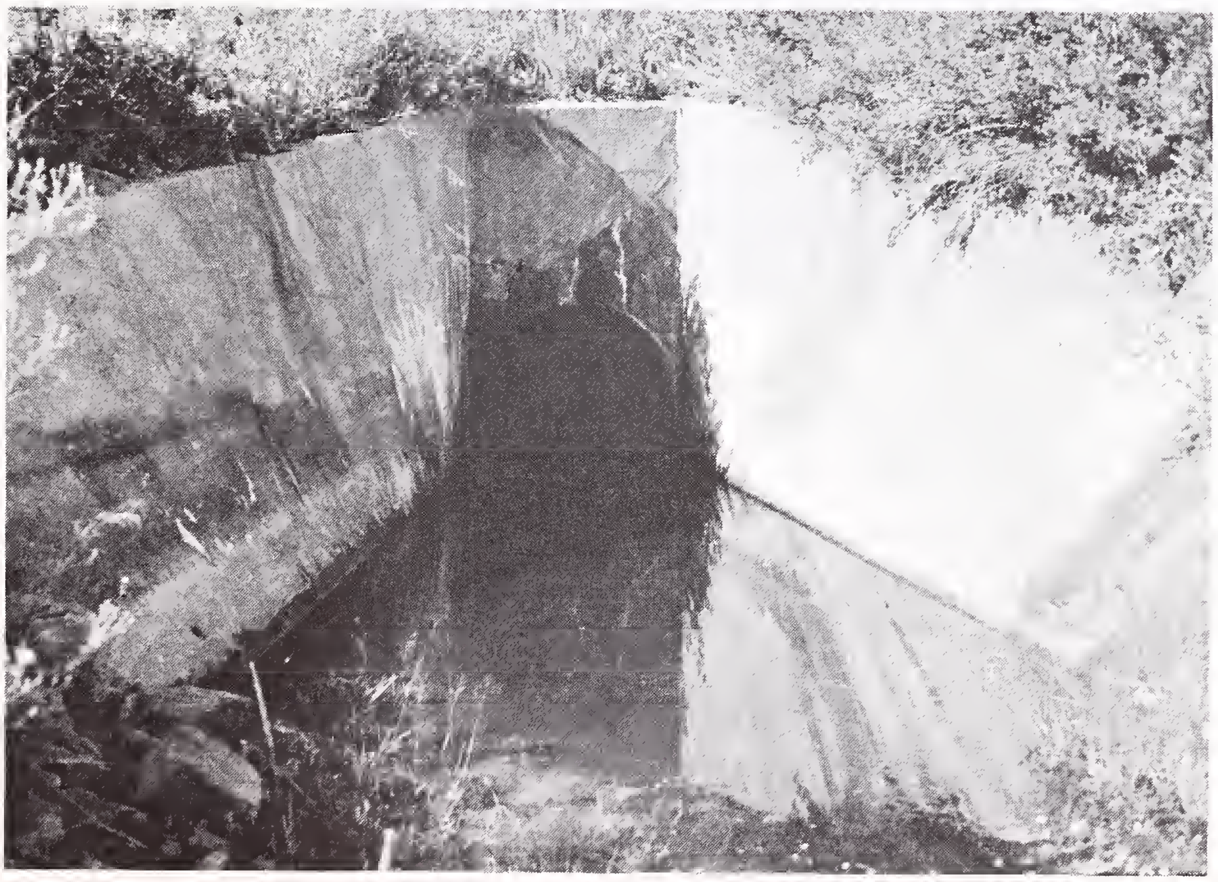


Photo 32. North Dam Outlet Conduit Section

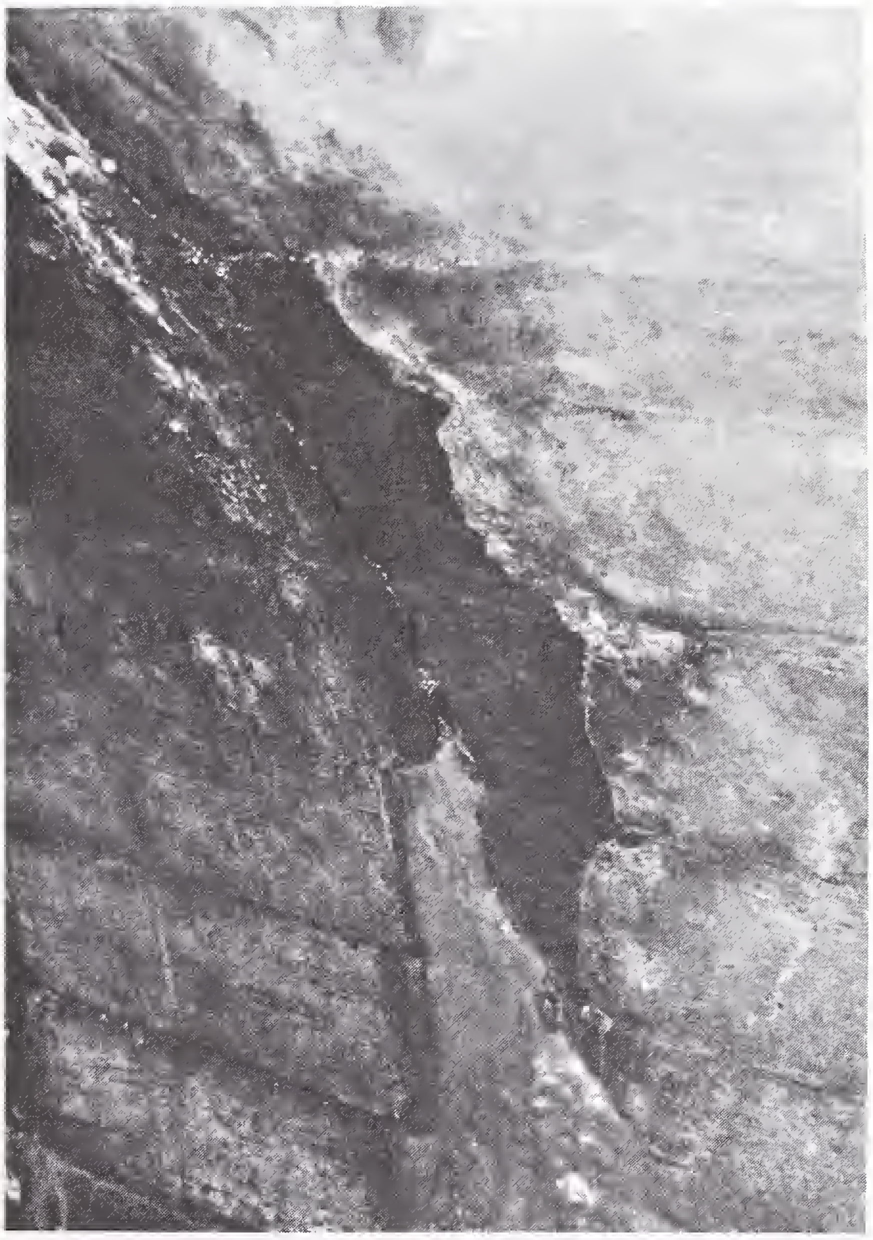


Photo 33. North Dam Crack in Conduit Wall 5-feet Downstream of Gate

Photo 34. North Dam Right Drain Pipe

Photo 35. North Dam Left Drain Pipe

APPENDIX

Correspondence

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

TED SCHWINDEN, GOVERNOR
32 SOUTH EWING
STATE OF MONTANA
(406) 449-2872 ADMINISTRATOR
(406) 449-3962 WATER RIGHTS BUREAU
(406) 449-2872 WATER SCIENCES BUREAU
(406) 449-2864 ENGINEERING BUREAU
(406) 449-2872 WATER PLANNING BUREAU
HELENA, MONTANA 59620

June 22, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Nilan Dams (MT-14) and (MT-3206). We concur with the findings and recommendations and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that these will be included in the final report.

We sent copies of the report to the Nilan Water Users Association for their review and comment. They concur with the report findings and recommendations and chose not to comment.

Thank you for this opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L. Bondy, P.E.
Chief, Engineering Bureau

RB:LT:lz

"AN EQUAL OPPORTUNITY EMPLOYER"

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QUALITY ASSURANCE

QA

Rodger C Foster

Project Manager

Thomas M. Watson

Branch Manager or Department Head

Philip J. Porrini

Peer Reviewer

C.W.

Principal-In-Charge

Chief Engineer No. 81-13	Date Approved 7-23-81

Project No. 1447-009-05 (33)